

STUDIES IN PATTERNS OF GRAIN DISTRIBUTION IN SCOTLAND
1866-1966

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Abstract

The major problems in studying the patterns of grain distribution in Scotland between 1866 and 1966 are regarded as methodological and representational. The physiographic face of the country presents a strong character of its own which threatens to dominate any representational form attempted. Different methods are experimented with, to provide representational forms which improve the presentation of ratios and fixed situations. The methodological approach is designed to offer results which may be applied more widely.

The basic reference unit is the parish and the source material is to be found in the annual census of agriculture. Since the parishes vary widely in overall size as well as in the amounts of land usable for grain growing, a method is developed to compare characteristic patterns in units of like size.

The aims are few but they provide sharp limitations and harsh demands on the representational methods. A search for multi-component representation was essential in order to examine a variety of related activity at one time over the entire country. Areal comparability is a basic requirement. A measure of data retrievability is regarded as desirable so that the maps, diagrams and graphs are usable in other related fields. These aims are pursued throughout and the different methods which provide for some or all of the requirements are examined in turn until the most suitable form of representation has been found. The unit area comparative approach provides striking results.

A study of the patterns of grain distribution over the century reveals considerable change in Scotland. A period of optimistic expansion was succeeded by a long slow decline in grain acreage and production. The economic strain imposed by war led to government intervention and altered the grain-growing patterns for some years, checking the decline in grain growing in marginal areas. The problems of competition from cheaper grain imports from abroad led to a measure of protection for wheat growers provided through further government intervention. Despite this aid for wheat, the situation continued to be grave for Scottish farmers and the acreage of grain fell to its lowest point, before being expanded again to meet the demands of another war. The recovery was temporary and a further decline in grain acreage continued until the international market demand for the kinds of grain better suited to Scottish conditions, altered the situation in the last decade of the period.

The changes in market demand were matched by a revolution in farm practices. This involved the use of increased amounts of fertilizers, weed, disease and pest controls, mechanization, new seed varieties and the like to increase acreage productivity to heights seldom equalled even in the most favourable years. While farm grain output increased, the labour pool decreased and has been replaced in part, by heavy investments in specialized machinery. The resulting grain cropping patterns are less flexible to meet changing conditions and there is some loss of agricultural versatility.

Acknowledgements

During the progress of research numerous persons acted as official and interested advisors. Both professors in the Department of Geography took an active interest in the work, from the methodological and representational point of view as well as from the agricultural statistical source and mechanics point of view.

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Professor D.J.Finney, Department of Statistics offered most stimulating constructive criticism on the problem of achieving areal comparability and the dangers of representing statistics in lowland and upland areas of certain counties where the percentages of arable to hill land were completely different. The salutary remarks on a number of problems led in some part to the emphasis reflected in the aims.

Principal S.J.Watson, Edinburgh School of Agriculture, expressed a keen appreciation of the raw percentage ratios on the parish maps of Scotland and foresaw their use as a research tool by others in specialized fields who would supply their own scales and interpretations.

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The statistical material on the number pattern maps found in Appendices D and E were typed on direct image multilith masters using an Imperial typewriter fitted with Bijou type at 16 characters to the inch. The map was printed on the masters, from a tracing on opaque paper, by Office Printing Services Ltd., 21 Stafford St. Edinburgh. The text was typed on direct image multilith masters using an electric Underwood typewriter and pica type. All of this material was reproduced by offset printing. The maps, diagrams and graphs were drawn page size, but in order to present more than one for comparison, they were photographed and positive negatives made which were reproduced by dye-line reproduction.

STUDIES IN PATTERNS OF GRAIN DISTRIBUTION IN SCOTLAND
1866-1966

Introduction

Studies in the patterns of grain distribution in Scotland have been attempted for two reasons. Firstly, a century of annual statistics exist and, secondly there is a need for studies on the macro-scale over a substantial period of time.

Scotland is fortunate in having a century of annual agricultural statistics and a tradition of statistical gathering which predated the 1866 census by over sixty years, mainly on a local scale. The suggestion that a distributional study of grain patterns would be useful, came from officials in the Department of Agriculture (Scotland) and Edinburgh and East of Scotland College of Agriculture. A great deal of work on regional or county scales has been done over the years but an overall picture of the patterns which developed was needed.

The distributional patterns in the following account refer to Scotland as a whole. While the parish records have been used as the base throughout, the presentation of the material in maps and diagrams has made necessary the grouping of parishes, in areas of similar speciality pattern, into larger units. This study in patterns of grain distribution may suggest more detailed examinations on the county, sub-county, grouped parish or parish scale.

The title of the research uses the word grain intentionally to avoid some confusion surrounding the

terms corn and cereal in the century examined. In 1866, the term corn was used to include wheat, barley, oats, rye, beans and peas. The rye, beans and peas occupied about 2.7 per cent of the total. Since the statistics to be examined primarily involve wheat, barley, oats and a minor amount of mixed grain, the term corn was not suitable. The term cereal would have been useful except that for many years rye was included under it as a green crop and accuracy of the acreages reported as rye-for-threshing only, may be questioned. Rye has been treated separately and has been found to be of minor importance in Scotland. Mixed grain (the mixed cropping of barley and oats sown together) has never been important except in certain isolated areas and in some difficult years. Since the object of sowing it is to obtain rough feed grains, mixed grain has been totalled with the other major grains under total grain acreages but otherwise appears only as the fraction of one hundred per cent not explicitly expressed when adding the percentages of wheat, barley and oats headings, in the number pattern maps.

Scope

The major problem has been recognized as methodological. The most important task was to sift a century of parish statistics and develop a series of maps, graphs and diagrams, which would give a good objective cross-section of the pattern developing. At the outset the physiographic face of Scotland presented a competing strong pattern of its own.

The irregular shape with its sharp division between highland-upland and lowland regions presented an uncompromisingly rigid character to any map. There is a ruthless predictability about the patterns which may develop, leaving very little scope for experiment and sharply confining grain regions to certain well-known arable areas. Lay sources have been prepared to claim that the results were forecastable before the research was carried out.

The same type of landscape exists in other similarly located northern countries where each has its strong pattern of rocky or high upland and limited confined, often scattered patches of lowland. A variety of research experience in Ontario and Quebec and also in similar territory in Sweden and Finland has produced a background¹ for the present research. Each region has comparable areas of expected concentration and vaster areas of slight adaptation for grain growing. Consequently, a study of distributions in Scotland, where a wealth of raw statistical material is readily available, has considerable application to studies in other northern countries.

To make such research applicable in other regions, a methodological approach is essential. In this case mechanics and methodology are considered as strictly separate entities. The mechanics of handling research material involves

1. As yet unpublished field studies in land use and abandonment in the Grenville Front area from Sudbury to Sault Ste Marie, Ontario 1962-1966 and a comparison of Finnish and Ontario-Quebec Clay Belt Settlements in Valijoki and Lisma: New Planned Settlements in Finnish Lapland, Canadian Geographer V(1) 1961, pages 24-35, maps.

decisions as to whether to use computer programs to cover all of the material, or just part of it, the amount of other machine aids to be employed and so on.¹ The stress here is on methods of presenting the machined data to achieve the most dynamic representation possible and providing a picture in depth.² "It could be argued that many of the limitations of modern geographical writing spring from the fact that geographers exhaust themselves making incomplete analyses by primitive methods, and thus have no energy left for the strenuous effort which good writing and penetrating generalization require."³ The amount of analysis has been strictly limited to provide only the most useful relationships. Much effort has been expended to provide a variety of map, graph, and diagram material catering to all of the pertinent parameters and building up to a final expression in trend surfaces.

1. A discussion on the mechanics of handling research material is provided by Storrie, M.C., and Jackson, C.I., in A Comparison of Some Methods of Mapping Census Data of the British Isles, The Cartographic Journal, 4(1)1967 pp.38-43.

2. A similar division of the essentials is made by Board, C., in Chapter 17, Maps as Models, page 690 in Models in Geography, Methuen, London, 1967, eds. Chorley, R.J. and Haggett, P.

3. The conclusion reached (page 137) by Coppock, J.T., and Johnson, J.H., Measurement in Human Geography, Economic Geography, 38(1962) pp.130-7.

Aims

All of the work has been rigidly bound by three major representational aims. These are; a search for multi-component representation, reasonable areal comparability, and retrievability of the data.

The multi-component aim concerns the representation of a variety of related activity at one time. Since there are three major grain crops generally grown on the same farm at the one time, they must be shown at some point in their relationships to one another. Scale problems prevent the showing of all of Scotland at the parish level of multi-component activity but this could be done at a county or regional level. It has been possible to assemble the more arable-lowland and less arable highland-upland parishes data separately in divided counties in number pattern maps by single years over the entire century. In these divided county maps the activity in the far north is readily comparable with that in the far south or anywhere else in the country at the same time. The divided counties and counties were also assembled into grain regions but because of a loss of detail in the large highland-upland parts of the divided counties these larger regions have been less useful. The highland upland parts of the divided counties showed an affinity of patterns and usages akin to the traditions, outlook and general physiographic limitations of the more arable lowland part of the same county or the nearest arable-lowland neighbour.

The grouping of parishes according to ability to grow

grain and the division of most of the counties into two parts has assured a measure of comparability of similar areas. Very small parishes have been grouped into larger units to improve areal comparability. The number pattern maps have the advantage that the rounded statistics are retrievable from them. Retrievability of the data is desirable so that the maps and diagrams are usable by a wider group of researchers in related fields.

Other means of achieving the three aims have been found in the use of sections, raised statistical surfaces and trend surfaces. These and other approaches are representative of the best of the available techniques. A great many representational devices were not attempted because of their limited application at the scale chosen or as a result of non-compatibility with the aims.

Division of the Topic

The research is presented in two main sections. The first part is methodological and deals primarily with a variety of methods of representation. A critique of each approach is offered. The scale is the map of Scotland taken as a whole presented on a trimmed A4 sized sheet and the presentation is bound by the three over-riding aims.

The second section deals with the patterns of grain which have developed in Scotland over the century. The different methods of presentation are expanded and given in full. An assessment of the value of each approach is continued throughout. A cross-sectional sampling of years was first attempted but later expanded to include a

selection of peak and trough years as well as more normal years, so that the extremes and the average patterns are fully covered by maps, graphs and diagrams.

A variety of statistical representation is attempted illustrating the most recent developments in the field. The patterns are obvious from the maps and a lengthy discussion is not intended. A large amount of supplementary material by single years is provided in the appendix section. This provides a link between the years selected for major comparison on the maps and retrievable data for local more detailed comparisons.

The patterns which have developed over the century are influenced by natural controls, such as climate which plays an important role in the varying production patterns, on both the macro- and micro-scale. It is on the micro-scale that a vast amount of research is required. Studies of the patterns resulting from differences in slope, aspect, drainage, soils, soils temperatures and so on, are needed and could provide fascinating results.¹ The present emphasis is on the broader macro-scale and reveals country-wide patterns only. On this scale the effect of simply rotating the crops around the available croppable fields within the usual crop rotation pattern is enough to explain changes of one or two per cent in the parish. The existence of the

1. For examples of such specialized research see Weather and Agriculture, Taylor, J.A., Ed., Pergamon Press, London, 1967. There are chapters entitled -Growing Season as affected by land aspect and soil texture, and -Soil Climate by Taylor, Validity of soil temperature records, and -Wind as a factor in Hill Climates, By Sarson, P.B., as well as others.

Crofting Act¹ which provides a subsidy per acre of certain cereals grown, helps to explain the continued persistence of grain crops in regions not well suited to their growth, or where in most years it is difficult to harvest a properly ripened crop and store it in good condition. The almost complete withdrawal of horses and their substitution by tractor equipment has freed a good deal of land, some of it marginal, for grain production. This is a significant factor in explaining the increases in acreages reported in some areas.

On the macro-scale the most significant and sharply obvious patterns are those related to the exigencies of war and the overall national and international economic situation. Scotland's patterns follow the peaks and troughs of production common in Western Europe after the flood of New World grain exports reached the markets in the last quarter of the nineteenth century. The deep lows of production in 1914, 1931 and 1939 and the peaks in 1918 and in 1942-3 are also part of patterns shared with similar northern countries. The recent concentration on production of a superior quality of barley is not so general however. From the international viewpoint it is apparent that the Scottish (and general British) concentration on feed grains particularly barley, is a more sensitive response to international market requirements than the production pattern

1. For a discussion on land improvement grants under the Crofting Act, see sections 27-36 on pages 14-19 of the Advisory Panel on the Highlands and Islands, Department of Agriculture and Fisheries (Scotland) Land-use in the Highlands and Islands, HMSO, Edinburgh, 1964.

of some of the world's largest surplus grain-producing¹ countries.

The Basic Data

Scotland possesses a great wealth of historical and statistical information at the county and individual parish level. There are numerous descriptive studies done on individual counties, some of considerable antiquity, supplying useful arable and total acreages of crops of parishes and attempting to deal with problems of climate and elevation in some instances.² Some of the more arable counties such as East Lothian have a very large collection of historical agriculture references. This historical material has been worked over by experts to provide numerous papers in agricultural, archaeological, geographical, historical and other journals. "The problem for the geographer, as distinct from the historian, is that he needs comprehensive data for either a consideration of distributions or regional variations. Ideally such data would exist for each farm in an area, but these are rarely available at present, let alone in the eighteenth century. The next best thing is data on a

1. From a Brief by the Directors of the Manitoba Pool Elevators, to the Provincial House of Commons, in April 1967, where they recommend "that a crash program be implemented for feed grain and corn production." As reported under an item entitled "Future Wheat Markets may not be unlimited" in the Western Producer, Saskatoon, Saskatchewan, November 2, 1967.

2. See McGregor, A., Reports on the Statistics of Various Parishes in Scotland 1627, Trotter, J., General View of Agriculture of Linlithgow, Statistical Report of Scotland, 1794, Webster, D., Topographical Dictionary of Scotland 1819. These books are preserved in Register House, Edinburgh. Others on similar topics may be found in both Register House and the National Library.

parish basis and here there are a fair number of statistical returns available."¹ Instead of individual farms Claeson² suggests a basic grid of one kilometre square sections which might be assembled into regions and sub-regions for a variety of purposes. Because of the complex shape, size and often scattered patterns of British farms, general data on the per farm basis would be very valuable. However the census preserves the privacy of the individual farm reporting unit and offers the data at the parish level. Coppock has suggested that "...13,000 parishes of Great Britain provide as fine a mesh as is needed for most national or regional studies. But these data have certain characteristics which, if not properly appreciated, can lead (and have led) to quite erroneous conclusions."³ Drawbacks listed were that land which should have been returned sometimes escaped enumeration, land-use categories have not been defined in the same way over the years and the data cannot be precisely located but only in a general way by parishes.⁴ Despite these limitations the parish is

1. Commentary on page 80 of the paper by Grigg, D.B., *The Changing Agricultural Geography of England: A Commentary on the sources available for the reconstruction of the agricultural geography of England 1770-1850*, Institute of British Geographers, Trans. 41, June 1961, pp. 73-96.

2. See page 286, Claeson, C-F., *Co-ordinate System Map of Population Distribution in Sweden 1960*, Geografiska Annaler XLV (1963) 4, pp. 282-287. Claeson presumes census gathering on the one kilometre grid in the future.

3. See page 7, Coppock, J.T., *The Geographer and the Use of the Land*, The University of Edinburgh Inaugural Lecture No. 29, pp. 1-23, May 17, 1966.

4. Coppock 1966 as above - further paraphrased comments. In Coppock, J.T., *The Parish as a Geographical Statistical Unit*, Tijdschrift voor Economische en Sociale Geografie 1960, 51(1) pp. 317-26, there is a discussion of the parish as a totally unsatisfactory unit for the mapping of agricultural phenomena.

the only useful reporting unit available in Scotland and it is a more precise unit in the more arable lowland areas than in the undifferentiated highlands. The collection of agricultural statistics using a uniform grid reporting unit census base in the future may help to eliminate most of the difficulties in associating statistics with their proper source area on the ground. Such a development should make possible the assembling of the base units into meaningful groupings for a great variety of specialized research.

Census Sources

Prior to the consecutive annual collection of agricultural statistics which began in Great Britain in 1866, there were a number of attempts in Scotland to collect information which set the pattern and educated the public in reporting statistics. "The Farmers of Scotland have practically satisfied themselves that the inquiry is in no respect inquisitorial and that it cannot possibly divulge or compromise individual interests."¹ The first two Statistical Accounts of Scotland had already been issued in the years 1791-1799 and in 1845.² Although much of the statistical information was based on estimates there were other experiments in the collection of material. Examples are

1. A quotation from a statement by Hall Maxwell in 1856, found on page 3 in *Agricultural Statistics for Great Britain 1869*, by Fonblanque, A.W., Statistician, Statistical Department, Board of Trade, Whitehall, December 1869.

2. For an interesting discussion about the achievement of the Statistical Account 1790-97, see Mitchison, R., *Agricultural Sir John, Geoffrey Bles, London, 1962* pp 120-136.

provided by the Board of Trade acting as an agency collating material solicited from and supplied by village school headmasters to the County of Midlothian in 1845.¹ Later, the Highland and Agricultural Society of Scotland received a Treasury grant which was used to collect agricultural statistics in the counties of Haddington, Roxburgh and Sutherland.² Then a very ambitious first agricultural census was carried out over the whole of Scotland between 1854 and 1857 by the same Society. In 1857 crops in the County of Linlithgow were measured and recorded on maps by the Ordnance Survey.⁴ Unfortunately the census was not continued after 1857 for lack of a grant.

The organized agricultural census resumed in 1866 when the Board of Trade of Great Britain was responsible for the collection of the statistics. The Agriculture Act 1889 set up a Board of Agriculture and the direction of the census was transferred to it. This First Series of parish summaries continued to 1911 when the responsibility for the Scottish section was transferred to the newly organized Board of Agriculture for Scotland.

One agricultural census was taken annually, in June of each year from 1866-1911 and the collected material collated on the parish basis. During the period a number of variations were made in the minimum size of holdings reporting crops.

1. Reported in Parliamentary Papers 1847 LIX (468)11
 2. " " " " 1852-3 CI(917)163
 3. " " " " 1854-5 XLVII(1876)637
 1856 LIX(2)369, 1857 XV(2154)1 and 1857-8 LVI(2307)333

4. Preserved in the National Library Map Collection, Edinburgh.

In 1866 returns were requested from all occupiers of holdings larger than five acres. In 1867 and 1868 no minimum was suggested and in 1869 a minimum of one quarter of an acre was adopted and maintained for over 20 years. In 1892 a minimum of one acre was substituted and continued to 1911. During the 1866-1911 period live-stock was reported irrespective of size of holdings and the parish summaries entered on additional sheets. Other changes in the scope, definition and subdivision of classes collected went on continuously throughout the period.¹

The Second Series of Parish Summaries, began in 1911 with Scotland taking the responsibility for its own area. The actual distribution and collection of the schedules was done by the Board of Customs and Excise until 1919 when the Scottish Board of Agriculture assumed the task. The Second Series began with an annual June census and covered all holdings over one acre in size. Since 1933, all phases of distribution, collection, and tabulation were brought together under the Department of Agriculture, Scotland.²

Collections were made on a voluntary basis during the First Series 1866-1911 and the early part of the Second. No statutory powers were given the government boards or departments concerned, to compel proprietors to make returns or to exact penalties for giving false information. Where the

1. From a note preceding the Catalogue of AF 39 (First Series) in Records of the Department of Agriculture and Fisheries for Scotland AF 1-41, Catalogue Room, Register House, Edinburgh.

2. Scola, P.M., A Century of Agricultural Statistics, Scottish Agriculture, Autumn 1966, pp. 165-168.

returns showed obvious defects, parish experts were asked to supply estimates for the missing data. Original farm returns were considered strictly confidential and were destroyed after collation on the parish level. The parish level of reporting represents the smallest basic unit available for research at the present time. In addition to the parish material the original manuscript sheets for Scotland and county totals are preserved, and these may be checked for endorsements dealing with discrepancies, interpretations, definitions, proportions of estimated to actual returns and other details on the collection of the information.

Compulsory returns were made mandatory for the first time under the Corn Production Act 1917 but when the act was repealed in 1921, the compulsory powers disappeared. The Agriculture Census was finally given statutory powers and provision made for compulsory returns by the Agriculture Returns Act 1925 and these provisions were continued in the Agriculture Act 1947.

Since 1939 other agriculture census have been carried out at other times of the year besides June. The information from these have been summarized and are available at the county and whole of Scotland basis, in annual abstracts. The results of the December Census (from 1949), the March Census (1940-1952) and the September Census (1940-1950) are to be found in the HMSO annual publications, Agricultural Statistics, Scotland. Numerous changes have been made in the scope of the census. Few of these affect the accuracy

of grain reporting.¹

The Collection of the Parish Data

From the beginning the parish records were searched to provide reliable statistical reference material relating consistently throughout to the same parish. Lists of parish names were kept together with the old number system by the counties before 1933 and the new 1-891 numbering system following that date. Most of the errors found were introduced by the occasional reversing of the order of some of the parishes. Since they vary in size, an established pattern became recognizable and when this was broken a check was made of the anomaly.

Up to 1900 parishes (or parts of them) were still being shifted from one county to another until the present counties achieved the size and the title which they have held since 1933. In 1866 Abernethy and Duthil (Inverness) and Inveravon, Keith and Boharm (Banff) parishes were found in Elgin (Moray). The data for such parishes was transferred to Inverness and Banff since that is where those parishes have been listed for the past 75 or more years. Parts of the present Banffshire parishes were once reported in Aberdeen but have been entered throughout the century in Banff, where they have been located since 1900. Similarly parts of parishes or whole parishes

1. Detailed discussions on the Origin and Development of Agricultural Statistics, the Accuracy and Comparability of Agricultural Returns as well as an Evaluation of British Land Use Statistics may be found in Best, R.H., and Coppock, J.T., *The Changing Use of Land in Britain*, Faber and Faber, London, 1962, in chapters 1, 2 and 10. A further exhaustive critique is to be found in Coppock, J.T., *An Agricultural Atlas of England and Wales*, Faber and Faber, London, 1964 in chapter 1, and in Coppock, J.T., *The Statistical Assessment of British Agriculture*, Agric. History Review, IV (1957) pp. 4-21 and 66-79.

which are now in Perth, Fife, Angus, Kincardine, East Lothian, Peebles, Roxburgh, Selkirk, Renfrew, Stirling, Caithness, and Sutherland etc. which were reported in part or as a whole in other counties, have been added to the parish or county where they are now found.

Facts were gathered on a consistent format to be readily usable for electronic machine calculation. The categories covered were the number of census returns, the sizes of units reporting, the acreages of wheat, barley, oats and mixed grain, acreages of crops and grass, rye, rough grazing, tilled and arable area, regular fulltime male employees and regular part-time male help. When all of the data was assembled, it was found that the category number of returns reported was given more or less consistently to 1906 and dropped thereafter. Enough evidence was available in this non-compulsory period of the census to show that the returns were being sent back consistently more particularly from the better arable lowlands. The patterns of the reported acreages in a sample of widely separated parishes which were examined for reliability in cross-section remained remarkably consistent throughout the country.¹

The category- sizes of units reported was offered on a parish basis in a number of widely separated years such as

1. Cross-sectional line graphs were drawn for the parishes: Birsay and Harray (Orkney), Wick (Caithness), Cawder (Nairn), Skene (Aberdeen), Errol (Perth), Dunfermline (Fife), Abercorn (West Lothian), Coldingham (Berwick), Kirkpatrick-Fleming (Dumfries), Old Luce (Wigtown), Ayr (Ayr), Campbelltown (Argyll), and Harris (Inverness). Peaks and troughs were consistent by regions which might be expected to have similar cropping regimes.

in 1906,1926,1930,1935,1936,1946,1961 and 1966. They were grouped into those between 1-5 acres,5-50 acres,50-300 acres and over. Since the amount of grain grown in the various sized units was not available,this category did not prove useful for the purposes of this representational research.

Acreages of wheat were given separately under winter and spring wheat headings for over 40 years up to 1954, when only the total was reported. The relative importance of the two sowings is limited but it has been used. In the early part of the century bere and barley were included under the one class. Since rapid strides were made in plant breeding early in the century, the combination of the more primitive grain with barley does not seem to have introduced a significant error. Mixed grain was found to be unimportant except in occasional years in the north and western part of the country. It is totalled with wheat, barley and oats under total grain. The rye data has been kept separate from the rest of the grain. It is a class which is difficult to use,because a very great deal of the rye sown is meant to supply a green crop either for pasture or for winter fodder. The census attempts to get around this difficulty by asking for a separate sub-class on rye-for-threshing.

The most consistent consecutive data reported annually is that for crops and grass. This has been accepted as reported by parishes,but with the understanding that the varying vantage points in the more highland-upland as compared to the more arable lowland areas are bound to confuse the category. Improved grass may mean something

quite different in Fortingall and Eyemouth. Differences of classification may have injected a small percentage of error when crops and grass was used consistently throughout as the base reference point. Other categories such as rough grazing acreages were collected in widely separated years but the base was not always consistent. In 1937, the data was collected under the title Rough grazing, in 1938 as rough and mountain grazing, in 1943 and 1948 as total crops and grass and rough grazing, in 1953 and 1960 as separate rough grazings and in 1963 and 1966 as rough grazing within the farm unit.¹ The tilled area was reported by parishes in 1942 and 1946 and the arable area in 1953 and 1956. This data is useful in spot checking but is not comparable throughout on the parish basis.² Details on regular full-time and regular part-time male labour were kept since first offered in 1921, in order to study the availability of labour since that time. At the outset, there seemed a strong possibility that the adoption of machine methods (so appropriate to grain farming) would lead to increasing acreages being devoted to grain as the pool of labour for the more labour-intensive crops ceased to be available.

1. A discussion on the Inherent Limitations of the Statistics, may be found in pages 13-16 of Coppock, J.T., Relationship of Farm and Parish Boundaries, Geographical Studies 2(1)1955 pp.12-26.

2. Arable area data is available more frequently on the county basis and annually on the whole country basis. When a data bank of agricultural census material is created, such categories could be obtained as required.

The Collection of County Data

Estimated yield data has been available annually since 1885 by counties. Until 1921 the yields were given in bushels and thereafter in hundredweights. The estimates before 1921 have been converted to hundredweights using the weights per bushel suggested for each year ¹ when available or when the annual suggestions were not given then the official standard weights were adopted.

The examination of Scotland as a whole requires the study of output as well as basic acreage data. The output material is based on official estimates which have not been published after 1965. The quality of the estimates varied somewhat from the more arable lowland where the fields were of a reasonably recognizable size and uniform fertility, to the scattered fragmented tiny arable areas of the highlands and islands. Throughout, the estimates were given on a county basis and represented the averaging of estimates over highlands and lowlands alike. Despite these drawbacks, they were compiled by regional experts from a number of checkpoints across the country. It is readily apparent that estimates of yield made when the grain is on the stalk may vary somewhat from the actual yield taken into storage. However over the period, there is no other usable yardstick for production, and the output data is used with an understanding of its basic drawbacks. ²

1. These weights varied with the growing and harvesting conditions annually.

2. A critique on Crop Estimating and Forecasting may be found on pages 449-469 in Venn, J. A., *The Foundations of Agricultural Economics*, Cambridge University Press, 2nd edition 1933.

Other Sources

The colleges of agriculture at Edinburgh, Glasgow and Aberdeen, together with their local offices and field centres, offer a great deal of material related to specific varieties of grain production and average acreage yields under measured conditions. Most of this material would be suitable for intensive localized, shorter-term studies in-depth, where patterns and distributions vary according to height, aspect, slope, drainage, soil, ground temperatures and so on. Records are kept of sample plots and graphs have been prepared to supplement reports made on the experiments. The trials do not continue for long on one site and new sample areas are adopted frequently. For a study of long-term patterns of crop varieties widely in use on the farm, the material lacks continuity. This material was not readily related on a unit basis to the parish statistics. It may be more suitable to detailed county or parish studies.

Basic Working Methods

The original parish data was collected on standard divided accounting sheets over a period of full-time work lasting three and a half months. The aim from the start was to provide the century of basic material in a form which could be readily used for machine calculation. The

1. Other reference material from which local patterns may be discovered may be found at the Scottish Society for Research in Plant Breeding, the Macaulay Institute for Soil Research, the Hill Farming Research Organization, the Royal Highland and Agricultural Society, regional agricultural offices and other research organizations.

statistics proved to be so bulky that an estimated period of up to one year would have been required to transfer it to cards or magnetic tapes. Initially there appeared to be far too much data and too few standardized operations required which would lead to lengthy periods of computer time.¹ The suggestion was made that the analysis be done on an electronic calculator so that trends would be observable as they developed.² Accordingly the preparation of percentage ratios, separating of counties into divided counties and grouping into regions, was contracted out. During the three months required for this stage of machine calculation, the percentage data was entered on blank parish maps of Scotland. At an early stage patterns were observed which led to the division of 19 counties into more arable and less arable parts to obtain 54 units and finally the grouping of these into 12 grain regions. Some of the very long parishes cut across a variety of landscape and include a considerable percentage of rough uplands. These were examined on the ground during field trips and the grain acreage ascribed as nearly as possible to the actual area where grain was planted.

At the start the ideal cross-sectional views of the century appeared to be by grain regions. However there was a considerable loss of detail and the divided county and county 54 unit division of the country was adopted instead.

1. See the general advice offered on pages 16-17 by Green, B.F., *Digital Computers in Research*, McGraw-Hill, New York, 1963.

2. Advice offered personally by Schofield, P.D., and others in the Department of Computer Science, University of Edinburgh, during a programming course offered in April, 1967.

To locate the peak and trough years of production, the percented values of wheat, barley and oats in relation to total grain, and the total grain in relation to total crops and grass acreage, were entered on the graphs also. A base year was chosen at mid-century low production in order to give a graphed line of reference based on a single unchanging reference point, per parish and using crops and grass acreage as the base. The year 1914 was chosen as it appeared at the end of a long 40 year decline in grain production. This base line proved useful as a point of comparison. Sometimes the decline in reported crops and grass acreage proceeded more rapidly than the decline in grain acreage.

All of the material was handled by single years. This part of the work (not including the work contracted out) occupied a year. From the percentage parish maps, 185 graphs, 100 grain acreage number pattern maps, 81 production number pattern maps and 150 density maps were prepared. These were chiefly for working reference use, and they have been condensed into the map, graph and other representational material used in the main body of the analyses of grain patterns. Other sections are supplied as reference material in the appendices.

Summary

The base unit used for analysis was the Scottish parish. Very small parishes in the highly arable coastal lowlands have been grouped into larger units in some of the representational approaches. Comparability of data has been

achieved partly by carefully checking parish size and name from the start so that small errors have been eliminated and the data is reasonably consistent throughout. The most reliable base for comparison of grain-growing activities was found to be the crops and grass acreage by parishes. Though there were local difficulties in preparing this category, they seem most acute where grain growing occupies fragmented small scattered acreages, and consequently affect a small percentage of the grain patterns. The most useful subdivision providing good local colour without excessive loss of detail, was found to be the 54 unit divided county and county map. The more uniform counties were not divided. A variety of representational approaches have been attempted using parish, county, divided county and regional bases, in order to find the most dynamic, multi-component picture consistent with the other aims of general retrievability and reasonable areal comparability.

An order of magnitude of production was obtained by using estimated yields in bushels per acres which were published for the first time in 1884 but averaged for the whole of Scotland (there were five divisions of England and Wales). In 1885 the estimates were published on a county basis and for the first five years they were given a very rigorous review, a check of the parishes reporting, and notation of any swings from what was termed the "ordinary average yield"¹ to be expected. Since they are estimates the representational material based on them is kept separate.

¹ Agricultural Produce Statistics for Great Britain, Vols. LXXXIV, p. 223f. LXX, p. 237f., LXXXVIII, p. 495f., CVI p. 213f. for the years 1884-5, 1886, 1887, and 1888 respectively.

Methodology

Approach to Mapping

Numerous problems were posed by the ambitious aims.

At the beginning density maps were known to give a static exclusive picture of one crop pattern at a time.¹ Such maps are highly predictable in appearance since they are imprinted with the strong physical pattern of the country. Despite these drawbacks, density maps are not available showing the grain patterns in key years up to a century ago, so such maps have a historical value. They are also more dynamic and useful for comparative purposes when more than one map-year may be seen at one time.

A view in depth in one area at a time was obtained by constructing cross-sectional line graphs from 1867 to 1966. Divided counties and counties totalling 54 units proved to be the most satisfactory base.

These and many other methods of representation suffer from flatness, the limitations of single dimension and a fixed time element. Several hundreds of such maps have been used as a background to writing but a more dynamic method of representation has been a major pre-occupation. Scotland has a variety of widely separated lowland areas suitable for the production of grain but the ability to produce it varies widely. An acre in the far north is an entirely different

1. A discussion on methods of mapping agricultural statistics, covering dot and choropleth maps and bar and proportional circle graphs, may be found in pages 22-24 of Coppock, J.T., Relationship of Farm and Parish Boundaries-A study in the use of agricultural statistics, Geographical Studies 2(1)1955 pp.12-26. Also see Coppock, J.T., The Cartographic Representation of British Agricultural Statistics, Geography 50(1965)pp.101-4.

piece of real estate from one in the Lothians. This essential difference was required on the maps. A multi-component picture of a multi-regional ability to produce was also required. When one crop is in vogue another is in eclipse. Since there are no reserve cropping areas to be called upon for expansion, changes in order of rank, mean the displacement of the old head of the order. It is helpful to know what form the new pattern takes at a number of points at the same time. An expression of the different scale of activity based on relatively fixed areas must also find an outlet.

How this has been attempted and comments on the value of each approach is offered in the following methodological section. The limitations are discussed as they apply to the mapping of Scotland as a whole. They are not a criticism of thematic methods of mapping in general since other methods than those employed are valuable under other less limiting aims. A variety of methods which are not suitable for mapping Scotland as a whole, are quite useful in the mapping of parts of it—regions, sub-regions, counties, sub-counties, parishes or parts of parishes, taken at a time.

An impression of the distortions and misrepresentations which arise when different base units are employed is offered in two sets of four maps, each using the county, divided county and counties, grain regions and parishes as the base unit. The same year is used in all of the maps. The first set deal with percentages of grain acreage in barley in 1966 and the second with actual acres of barley in 1966 (Figures 1 and 2). Most

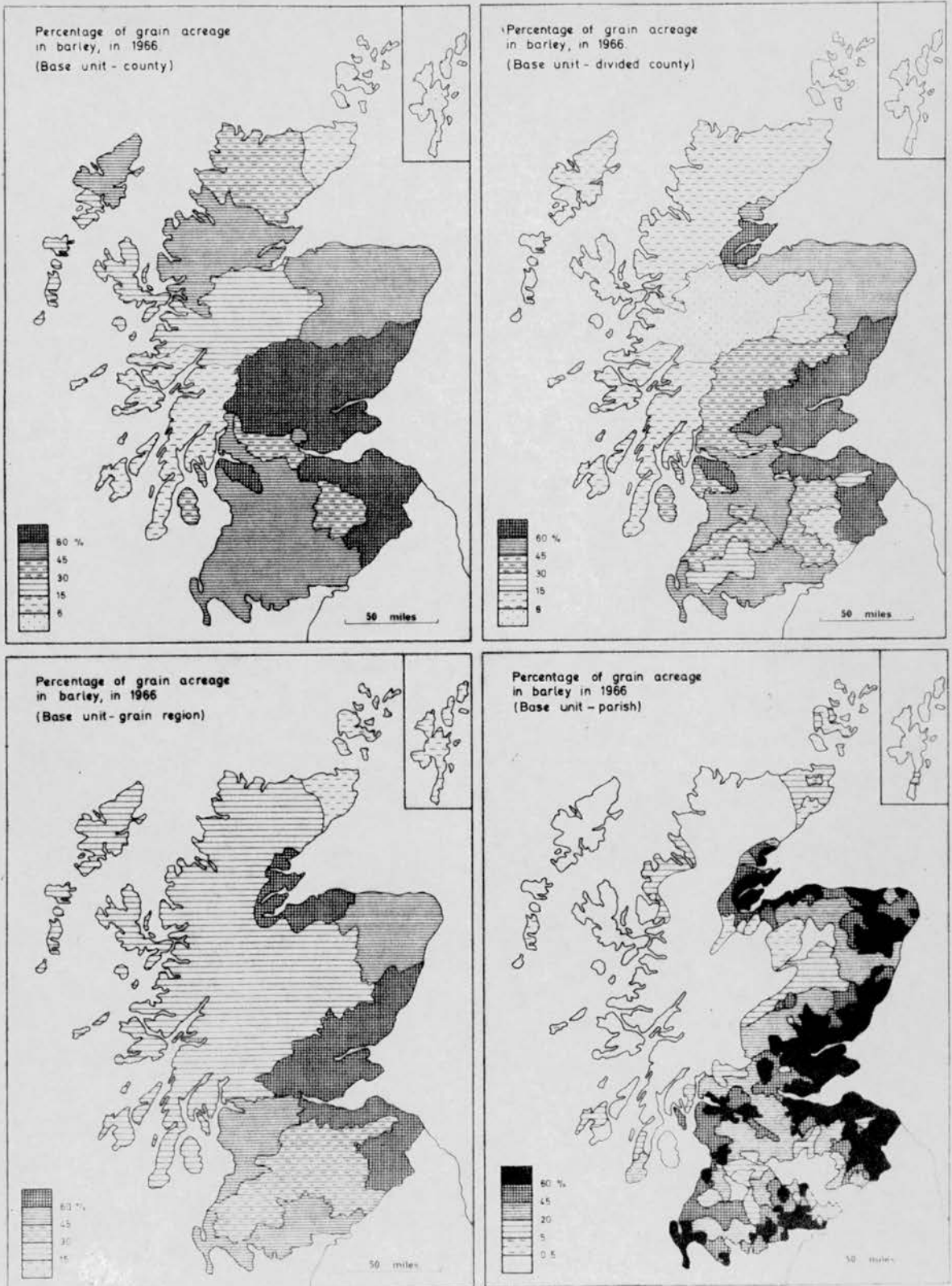


Figure 1

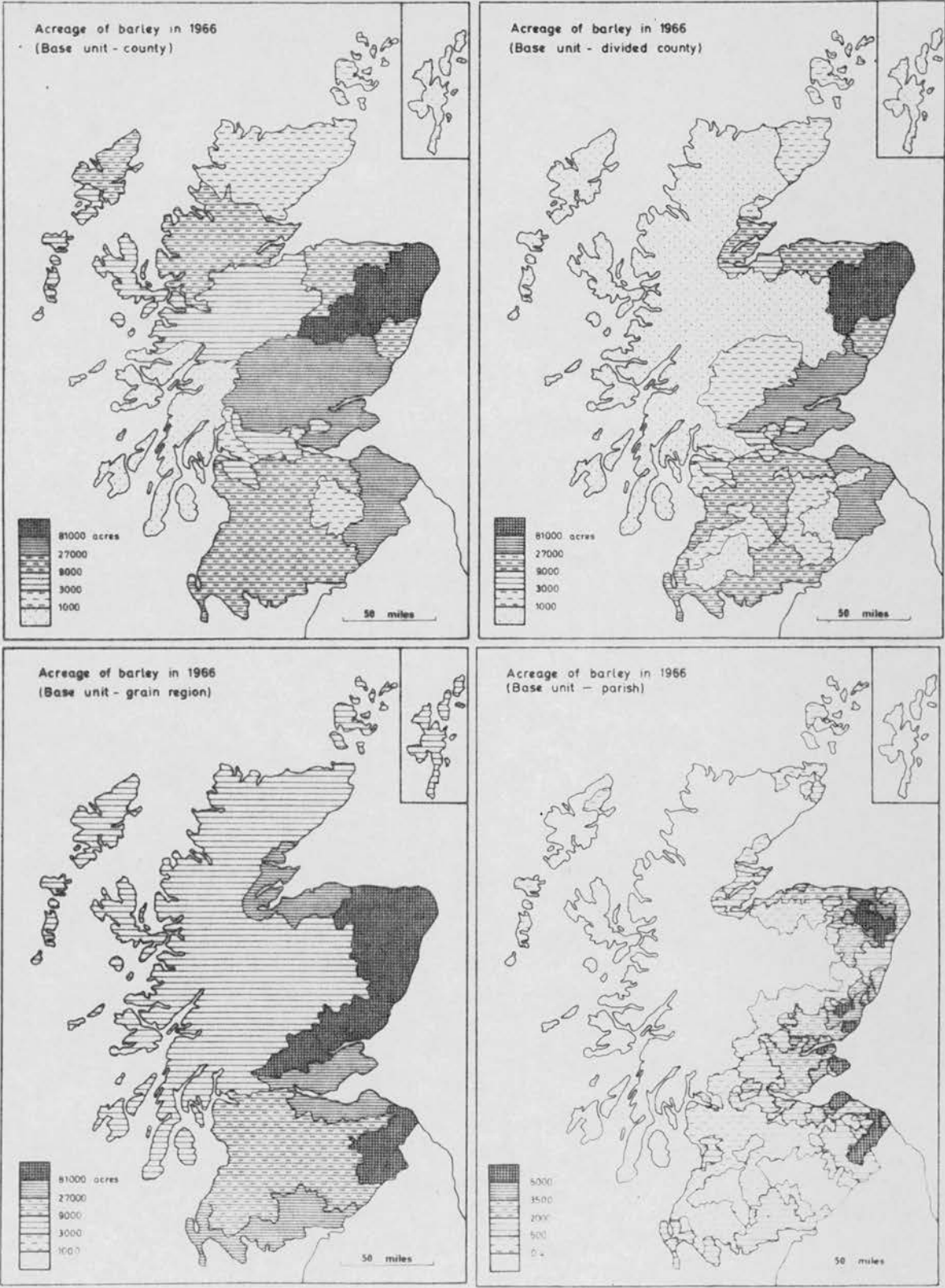


Figure 2

of the distortions are so very noticeable that they are not listed here. One misrepresentation which would be very misleading for the uninitiated examining the percentage maps, is the suppression of arable Aberdeen as the outstanding grain producing unit. Aberdeen's pre-eminent position is much more consistently portrayed in the actual acreage maps. The actual acreage map by divided counties and counties is much less patchy than the one showing percentages and expresses more clearly the limitations of the terrain. In all cases the parish map provides the smoothest patterns, but even these maps would give a misleading appearance if some field examination had not made possible the differentiation of more arable from less arable areas.

If the country was to be presented in three or more parts instead of one, more detailed eliminations of rough highland-upland areas from parishes would be possible. The result would be an increasing accuracy which would reach its height when data is relatable to the actual farmer's fields and all non-croppable land is eliminated. At the whole country level, where one or more maps are shown on a page, the ones offered supply a reasonable accuracy.

The Basis for Division into Regions and Divided Counties

Every county has areas of rough land and most of the grain growing takes place in the lower more arable areas. Certain parishes have both arable lowland and rough upland. The same divisions may be made on many farms. The bulk of the highland-upland area of Scotland is divided into 225 very large parishes and the more unified part of the arable

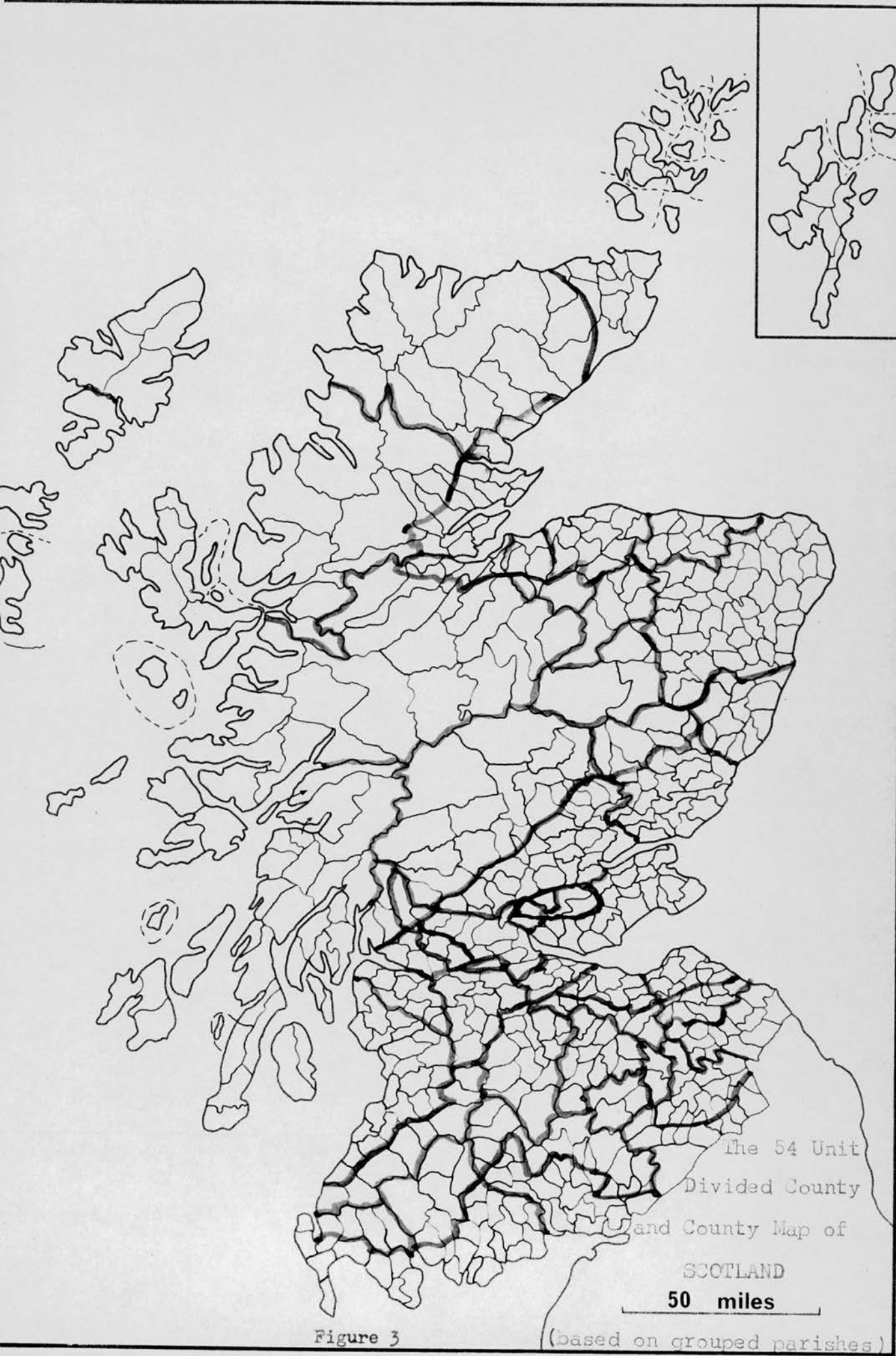
lowland area by 636 generally much smaller parishes.

Thirteen counties represent reasonably uniform entities and remain wholly in either lowland or upland. Nineteen others were divided into two parts along parish boundaries and one in three to make 54 units (Figure 3)¹. The counties which were not subdivided are East and West Lothian, Peebles, Fife, Kinross, Argyll, Renfrew, Bute, Shetland, Orkney, Caithness, Nairn and Kincardine. Parts of some of these counties were pared off and added to the highland-upland where there was only rough upland without possible land for grain growing. All of the other counties were divided into two parts representing more highland and more lowland areas by parishes, except Stirling which has grain farming attributes of three grain regions- the Forth, Ayr-Clyde and the Highlands. Accordingly Stirling was divided three ways along existing parish boundaries. The basis for these divisions² is outlined under Regional Patterns which follows.

Large parishes which were divided with some care, were all of those bordering on the narrow coastal arable lowland in Sutherland, Ross and Cromarty, Inverness, Nairn and Moray and the long parishes in East Lothian running into the Lammermuir Hills. Other more suggestive than accurate divisions were made in highland parishes along the western coast and bordering on the arable areas in Aberdeen, Angus and Perth. Arable land is so fragmented in highland valleys

1. The 54 unit division was carried out on a large parish map of Scotland but is shown here on a grouped parish map which is more suitable at this scale.

2. For the identity of the parishes in each division by their official numbers, see Appendix A.



that accuracy is impossible but some division was desirable to suggest that most of the grain cropping takes place in coastal valleys and inlets and in other larger interior valleys. All divisions were made after field work in the area, consultation with county agricultural officers and an examination of land use and types of farming maps.¹

Regional Patterns

Immediately recognizable regional patterns emerge from an examination of the percentage ratio maps. The map showing the percentage relationship of total grain and crops and grass acreages reveals the basic pattern. In 1966 highland-upland parishes generally show less than 10 per cent of the crops and grass acreage sown to grain. Island, southwest and southern areas have from 15-25 per cent of the same category in grain. These areas are represented in the counties of Orkney, Shetland², Caithness, Renfrew, Ayr, Wigtown, Kirkcudbright, Dumfries, and the Biggar-Lanark region. From 30 to 45 per cent of crops and grass is devoted to grain in the eastern lowland coastal areas of Ross and Cromarty, Inverness, Nairn and Moray and in a broader belt stretching through Banff, Aberdeen, Kincardine, Angus, eastern Perth and the Forth area. Even higher percentages 45 to 60 are to be found in the coastal areas of Angus, Fife, a narrow strip along West Lothian and Midlothian,

1. The Land Utilisation Map 1942, Land Classification Map 1944 and Types of Farming Map 1945, all of Scotland and part of a set published by the Director General, Ordnance Survey, were useful as well as the limited material available from the land use survey now in progress.

2. Officially spelled as Zetland since 1931 but widespread usage is Shetland and this was the spelling before 1931.

most of East Lothian, the Merse of Berwick and on into central Roxburgh.

Most of the last seventy years revealed a similar but not so extreme pattern with higher percentages of grain resorted in the coastal areas of the Lothians and very much lower ratios in Berwick and Roxburgh. Since patterns were similar in all the years for which crops and grass was available in published totals at the parish level, for comparison with total grain acreages, regional groupings suggested themselves. The prevalence of such limited-use crops as wheat and barley and patterns of grains in relation to each other, also aided in the delimitation of grain regions. From this analysis of the numbered percentage ratio parish maps over most of the century, certain grain regions have been separated. Sample tables of typical ratios are supplied under the condensed descriptions of the grain regions. Ratios for each year 1867-1966 and for each of the 54 unit divided counties and counties, may be found in Appendix D.

Grain Regions

1. Caithness, Orkney, and Shetland. Arable land is frequently found in scattered patches in this grain region. Little or no barley was grown until new varieties developed in the last decade or so have found some application under regional limits. Shetland has no wheat¹ and the other counties wheat on a very small or garden scale. The following patterns are typical of the century.

1. A trace of wheat was reported in 1944, 1946, 1956 and 1961 in Shetland and amounted to 1 acre each year except in the last when 2 acres was reported.

| | Caithness | | | Orkney | | | Shetland | | |
|---------------------|-----------------------------|------|------|--------|------|------|----------|------|------|
| | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 |
| Wheat ^a | t | t | 0 | t | t | 0 | 0 | 0 | 0 |
| Barley ^a | 5 | 3 | 13 | 19 | 5 | 5 | 20 | 4 | 1 |
| Oats ^a | 95 | 97 | 87 | 80 | 95 | 95 | 80 | 96 | 99 |
| Grain ^b | 32 | 27 | 22 | 39 | 29 | 21 | 21 | 21 | 13 |
| | a percentage of total grain | | | | | | | | |
| | b " of crops and grass | | | | | | | | |

2. Moray Firth

The coastal lowland areas of Ross and Cromarty, Inverness, Nairn and Moray, along with a very small part of south-eastern coastal Sutherland are included in this region. It is sheltered and grain is the most important arable cash crop. Barley has been grown over the century as well as smaller acreages of wheat.

| | L. Sutherland | | | L. Ross & Cromarty | | | L. Inverness | | |
|--------|---------------|------|------|--------------------|------|------|--------------|------|------|
| | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 |
| Wheat | 2 | 1 | 5 | 16 | 5 | 8 | 10 | 3 | 7 |
| Barley | 20 | 7 | 54 | 20 | 18 | 66 | 23 | 19 | 58 |
| Oats | 78 | 92 | 41 | 64 | 77 | 26 | 67 | 78 | 35 |
| Grain | 30 | 24 | 23 | 41 | 30 | 35 | 33 | 29 | 33 |
| | Nairn | | | L. Moray | | | | | |
| Wheat | 3 | 3 | 7 | 15 | 5 | 6 | | | |
| Barley | 26 | 30 | 52 | 31 | 32 | 60 | | | |
| Oats | 71 | 67 | 41 | 54 | 62 | 34 | | | |
| Grain | 34 | 34 | 35 | 32 | 37 | 39 | | | |

3. Arable Banff and Aberdeen

For most of the century, this was the heaviest oats producing region. Only in the five years to 1966 has it switched very heavily to the new varieties of barley and in 1966 barley occupied a greater percentage of arable land than oats. Wheat growing has also increased in the last few years to 1966. Hardier varieties of barley now provide the chief cash crop available to the region.

1. The year 1950 has been chosen as representative of the pattern for much of the century, and it is well before the changes to barley which mostly followed 1955. The 1867 pattern frequently resembles that for the past few years to 1966.

| | L.Aberdeen | | | L.Banff | | |
|--------|------------|------|------|---------|------|------|
| | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 |
| Wheat | t | t | 2 | 1 | t | 1 |
| Barley | 6 | 5 | 58 | 8 | 17 | 51 |
| Oats | 93 | 94 | 40 | 91 | 83 | 48 |
| Grain | 37 | 35 | 33 | 40 | 37 | 35 |

4. Arable Perth, Angus and Kincardine

For the greater part of the century this was the largest wheat producing region. More recently it has also become a barley producing region. Other cash crops than grain can be grown but when these are labour-intensive the preference seems to be for grain since it can be grown and harvested with mechanized equipment.

| | L.Perth | | | L.Angus | | | Kincardine | | |
|--------|---------|------|------|---------|------|------|------------|------|------|
| | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 |
| Wheat | 16 | 15 | 8 | 14 | 17 | 10 | 2 | 6 | 5 |
| Barley | 21 | 8 | 66 | 30 | 18 | 70 | 23 | 13 | 62 |
| Oats | 62 | 77 | 26 | 56 | 65 | 20 | 75 | 81 | 33 |
| Grain | 30 | 29 | 34 | 38 | 36 | 42 | 38 | 38 | 35 |

5a. Fife

Fife has been separated from the rest of the Forth Region because it has had a very long tradition of barley growing in the eastern coastal area (barley was the leading crop in St Monans Parish in 1866 and probably earlier) and barley has been well established over most of the county since 1948. A cross-section of years bear out this pattern.

| | 1867 | 1914 | 1918 | 1939 | 1942 | 1955 | 1966 |
|--------|------|------|------|------|------|------|------|
| Wheat | 23 | 18 | 18 | 25 | 22 | 13 | 10 |
| Barley | 31 | 27 | 15 | 14 | 17 | 32 | 77 |
| Oats | 46 | 54 | 66 | 61 | 60 | 55 | 13 |
| Grain | 37 | 28 | 33 | 26 | 36 | 30 | 38 |

Peak years are represented by 1867, 1918, 1942 and 1966. The two low years are 1914 and 1939, with the deepest depression represented by the latter. The Fife patterns resemble those of East Lothian more than any other.

5b. The Forth

This grain region is made up of lowland Clackmannan, eastern Stirling, West Lothian and arable Midlothian (Fife and East Lothian have distinctions of their own and have been treated separately although part of the Forth Region). Over most of the century the main grain order was oats, wheat and barley, and barley did not become dominant until the last decade. Other cash crops are grown as well as grain. Yields have always been higher in the total Forth Region than in any other.

| | L.Clackmannan | | | | Forth L.Stirling | | | |
|--------|---------------|------|------|------|------------------|------|------|------|
| | 1867 | 1942 | 1955 | 1966 | 1867 | 1942 | 1955 | 1966 |
| Wheat | 23 | 9 | 2 | 11 | 15 | 16 | 5 | 3 |
| Barley | 23 | 5 | 9 | 57 | 24 | 4 | 2 | 46 |
| Oats | 54 | 86 | 89 | 32 | 61 | 80 | 92 | 50 |
| Grain | 41 | 35 | 26 | 33 | 35 | 30 | 21 | 24 |

| | West Lothian | | | | L.Midlothian | | | |
|--------|--------------|----|----|----|--------------|----|----|----|
| Wheat | 12 | 21 | 12 | 7 | 19 | 23 | 14 | 13 |
| Barley | 24 | 11 | 21 | 68 | 30 | 19 | 33 | 68 |
| Oats | 64 | 68 | 67 | 25 | 51 | 57 | 53 | 19 |
| Grain | 33 | 38 | 31 | 39 | 35 | 37 | 31 | 34 |

6. East Lothian

This county has been kept separate as a regional entity on its own. Over the entire century farmers in this county have been able to divide their grain cropping equally among wheat, barley and oats, or change the order of preference at will. Barley became a preferred crop in Dunbar in 1866 (or possibly earlier) and in Whitekirk in 1875 and has so continued to the end of the century. From this base the barley dominant pattern spread through the county and into neighbouring areas. Other cash crops are grown but in the five years to 1966, grain occupied an increasing acreage since

it could be handled by mechanized methods and the manpower for more labour-intensive cropping so prominent in East Lothian, has become increasingly scarce.

| | 1867 | 1914 | 1918 | 1939 | 1942 | 1955 | 1966 |
|--------|------|------|------|------|------|------|------|
| Wheat | 29 | 15 | 19 | 22 | 19 | 14 | 20 |
| Barley | 32 | 43 | 28 | 46 | 46 | 60 | 72 |
| Oats | 39 | 41 | 53 | 32 | 35 | 26 | 8 |
| Grain | 38 | 33 | 39 | 30 | 40 | 38 | 49 |

7. Arable Berwick, Selkirk and Roxburgh

For the first half of the century the arable land in this grain region was mainly planted to oats. Between 1914 and 1922 the farmers seem to have found a cash crop in barley but the varieties then available were not very popular. Spring wheat was tried with some success in the thirties and during the 1939-1945 war. Barley was re-introduced in 1938 and from that year it has provided the chief cash grain crop to meet the conditions of the region.

| | L.Selkirk | | | L.Roxburgh | | | L.Berwick | | |
|--------|-----------|------|------|------------|------|------|-----------|------|------|
| | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 |
| Wheat | 4 | 1 | 0 | 7 | 8 | 7 | 11 | 11 | 7 |
| Barley | 19 | 20 | 48 | 29 | 31 | 70 | 31 | 42 | 78 |
| Oats | 77 | 79 | 52 | 64 | 61 | 23 | 57 | 47 | 15 |
| Grain | 19 | 19 | 19 | 26 | 26 | 28 | 33 | 31 | 39 |

8. Arable Wigtown, Kirkcudbright and Dumfries

During most of the century, this was a region of little or no wheat growing, a very small amount of barley and widespread oats, on the relatively small amount of land devoted to tillage. Most of the grain was consumed on farms devoted to livestock raising. In the last decade the pattern has changed remarkably and barley has become an important crop. Mechanized methods have been adapted to the region where the moisture regime frequently hinders harvesting.

| | L.Wigtown | | | L.Kirkcudbright | | | L.Dumfries | | |
|--------|-----------|------|------|-----------------|------|------|------------|------|------|
| | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 |
| Wheat | 10 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 2 |
| Barley | 3 | 1 | 67 | 2 | 1 | 55 | 2 | 1 | 60 |
| Oats | 87 | 97 | 31 | 96 | 97 | 42 | 95 | 95 | 37 |
| Grain | 30 | 21 | 17 | 20 | 16 | 13 | 26 | 21 | 18 |

Despite the swing to barley after 1960 this region devoted less land to grain in 1966 than in 1867.

9. Ayr-Clyde

This region includes arable Ayr, Renfrew, western Lanark, part of southwestern Stirling and lowland Dunbarton.

Dairying is a major farm activity and grain growing over the century followed a pattern predominant in oats but with a small amount of wheat. Barley has always been unimportant and reportable as a trace in most of the region until its sharply increased importance since 1963.

| | L.Ayr | | | Renfrew | | | L.Lanark | | |
|--------|-------|------|------|---------|------|------|----------|------|------|
| | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 |
| Wheat | 11 | 4 | 6 | 13 | 9 | 7 | 11 | 9 | 2 |
| Barley | 2 | t | 48 | 1 | t | 67 | 2 | 1 | 47 |
| Oats | 86 | 94 | 46 | 85 | 90 | 26 | 86 | 89 | 50 |
| Grain | 23 | 16 | 12 | 20 | 15 | 11 | 36 | 18 | 11 |

| | S.W.Stirling | | | L.Dunbarton | | |
|--------|--------------|----|----|-------------|----|----|
| Wheat | 5 | 6 | 2 | 14 | 9 | 4 |
| Barley | 5 | t | 47 | 4 | t | 54 |
| Oats | 90 | 94 | 51 | 81 | 91 | 42 |
| Grain | 20 | 17 | 10 | 27 | 19 | 13 |

The sharp drop in total acreage devoted to grain is consistently severe throughout the region. The patterns for 1950 are very typical for the greater part of the century while the other two years represent the unusual patterns at the beginning and at the end.

10. Highlands and Western Islands.

This very large area includes the highland parts of Dunbarton, Stirling, Perth, Angus, Aberdeen, Banff, Moray, Inverness, Ross and Cromarty, Sutherland, a part of Caithness and all of Argyll and Bute. Oats is the predominant grain crop and over most of the century the only grain grown. Small amounts of rye and mixed grain are grown in widely scattered areas. Much of the barley which is reported is grown in the Hebrides, Tiree, Mull and Islay.

| | H. Dunbarton | | | H. Stirling | | | H. Perth | | |
|--------|--------------|------|------|-------------|------|------|----------|------|------|
| | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 |
| Wheat | 1 | 1 | t | t | 2 | 1 | 3 | 2 | 2 |
| Barley | 2 | t | 46 | 1 | 1 | 42 | 21 | 3 | 37 |
| Oats | 96 | 99 | 54 | 98 | 97 | 57 | 76 | 95 | 61 |
| Grain | 20 | 15 | 7 | 17 | 17 | 8 | 21 | 18 | 14 |

| | H. Angus | | | H. Aberdeen | | | H. Banff | | |
|--------|----------|----|----|-------------|----|----|----------|----|-----|
| Wheat | 1 | 1 | 2 | t | 0 | 1 | 0 | 0 | 0 |
| Barley | 19 | 6 | 35 | 6 | 1 | 8 | 13 | 2 | 0 |
| Oats | 80 | 93 | 63 | 93 | 99 | 92 | 87 | 98 | 100 |
| Grain | 32 | 20 | 16 | 29 | 21 | 19 | 28 | 21 | 16 |

| | H. Moray | | | H. Inverness | | | H. Ross & Cromarty | | |
|--------|----------|----|----|--------------|----|----|--------------------|----|----|
| Wheat | 0 | 0 | 0 | 1 | 1 | 1 | 1 | t | 2 |
| Barley | 5 | 7 | 5 | 18 | 4 | 5 | 30 | 2 | 13 |
| Oats | 95 | 93 | 95 | 81 | 92 | 90 | 69 | 98 | 85 |
| Grain | 25 | 29 | 22 | 31 | 17 | 13 | 27 | 23 | 11 |

| | H. Sutherland | | | Argyll | | | Bute | | |
|--------|---------------|----|----|--------|----|----|------|-----|----|
| Wheat | t | t | 0 | t | t | 0 | 5 | t | 0 |
| Barley | 29 | 3 | 6 | 9 | 1 | 11 | 4 | t | 32 |
| Oats | 71 | 97 | 94 | 90 | 98 | 88 | 90 | 100 | 68 |
| Grain | 44 | 16 | 12 | 18 | 16 | 10 | 25 | 18 | 11 |

The highland-upland parts of Dunbarton, Stirling, Perth an Angus and the Bute-Rothesay section of Bute, show a remarkable swing to barley growing. This became apparent in 1963 and is represented by 1966 in the table. This swing is not apparent in the rest of the vast area.

11. Southern Uplands

Peebles is the only county entirely within this region and even it would be subdivided if a different scale was used for the presentation. The region includes part of Midlothian, East Lothian's share of the Lammermuir Hills, the upland parts of Berwick, Selkirk, Roxburgh, Dumfries, Kirkcudbright, Wigtown, Ayr, and Lanark. Lanark has been divided almost in half. As far as grain growing is concerned both halves produce about the same total amounts but the part ascribed to the Ayr-Clyde region grows more barley and has other possible cash crops. The region has grown oats for feed grain mostly, more recently some barley.

| | U. Berwick | | | U. Selkirk | | | U. Roxburgh | | |
|---------|-------------|------|------|------------------|------|------|---------------|------|------|
| | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 |
| Wheat | 0 | 2 | 0 | t | 1 | 0 | 0 | 1 | 2 |
| Barley | 16 | 15 | 24 | 9 | 8 | 15 | 5 | 2 | 9 |
| Oats | 83 | 83 | 76 | 91 | 91 | 85 | 95 | 97 | 89 |
| Grain | 23 | 17 | 14 | 27 | 15 | 14 | 9 | 10 | 6 |
| | U. Dumfries | | | U. Kirkcudbright | | | U. Wigtown | | |
| | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 |
| Wheat | t | 1 | 1 | 2 | t | 1 | 5 | 2 | 2 |
| Barley | 1 | t | 36 | t | t | 22 | t | t | 30 |
| Oats | 99 | 98 | 63 | 98 | 99 | 77 | 95 | 98 | 68 |
| Grain | 11 | 14 | 9 | 17 | 15 | 9 | 14 | 16 | 10 |
| | U. Ayr | | | U. Lanark | | | U. Midlothian | | |
| | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 |
| Wheat | 6 | 1 | 1 | 4 | 3 | 1 | t | 2 | 2 |
| Barley | 1 | t | 35 | 1 | t | 46 | 17 | 11 | 42 |
| Oats | 92 | 98 | 64 | 94 | 95 | 51 | 82 | 87 | 56 |
| Grain | 14 | 13 | 6 | 18 | 18 | 13 | 21 | 16 | 12 |
| Peebles | | | | | | | | | |
| Wheat | t | 4 | 1 | | | | | | |
| Barley | 13 | 2 | 38 | | | | | | |
| Oats | 87 | 94 | 61 | | | | | | |
| Grain | 24 | 18 | 14 | | | | | | |

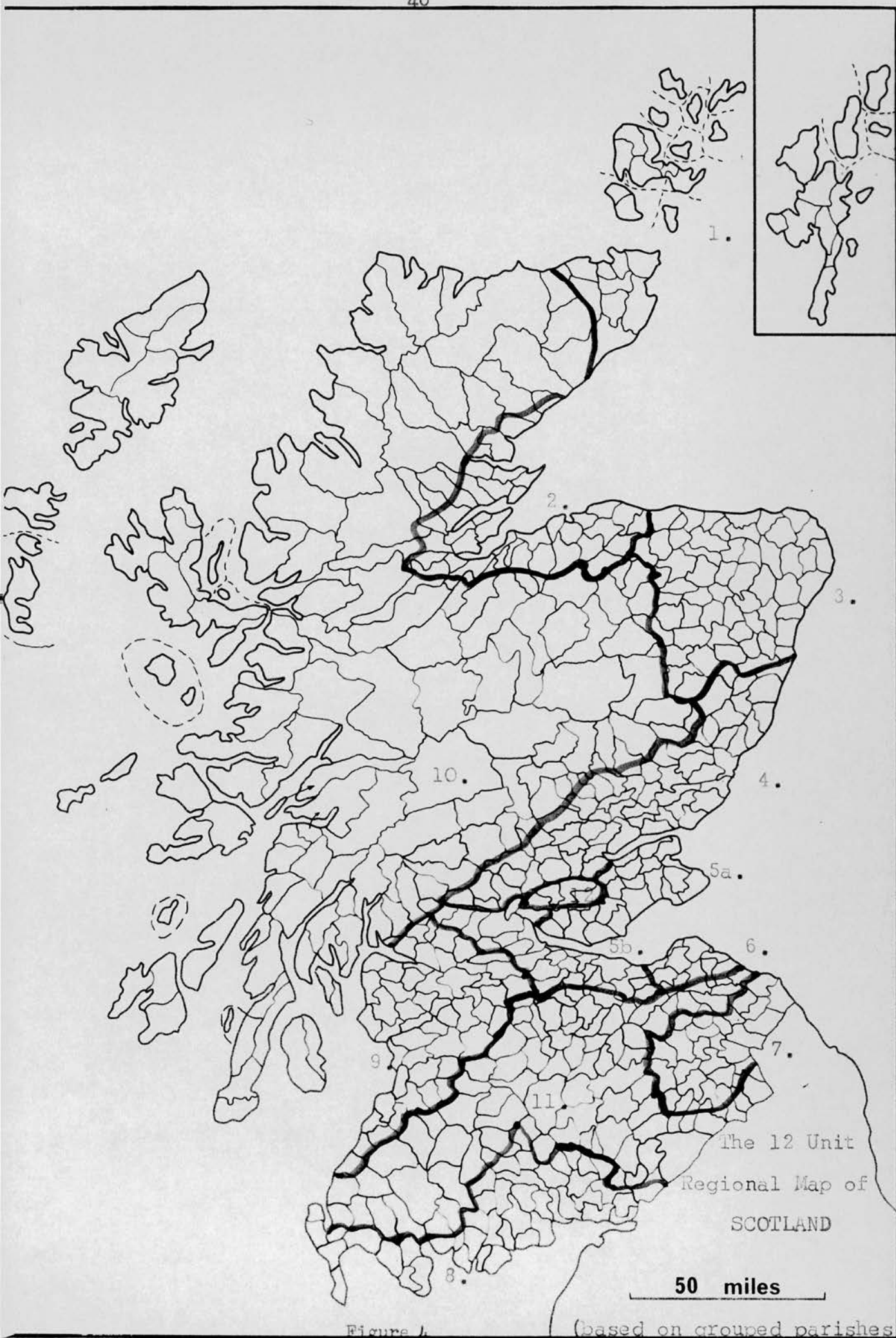
Although the Lammermuir Hills section of East Lothian is ascribed to this region no statistical division has been made.

12. The Ochils

This small upland region which might have been included in the highlands or southern uplands, has been left separate because it is geographically separated from either. It includes the greater part of Kinross, three parishes in Clackmannan and one from Perth in the Glendevon area.

| | U. Clackmannan | | | Kinross | | |
|--------|----------------|------|------|---------|------|------|
| | 1867 | 1950 | 1966 | 1867 | 1950 | 1966 |
| Wheat | 11 | 16 | 1 | 4 | 12 | 5 |
| Barley | 19 | 3 | 58 | 21 | 3 | 65 |
| Oats | 70 | 81 | 41 | 75 | 85 | 30 |
| Grain | 26 | 22 | 20 | 29 | 25 | 25 |

Since the last three regions lose a great deal of desirable detail when grain patterns are generalized for them as a whole, the preferred method of presenting the parish information within them is by divided counties and counties. A better pattern was achieved by using the 54 unit division than by the 12 unit grain regions, or by the 33 counties, for certain kinds of maps. When graphs were shown on the maps the 12 unit division (Figure 4) was the more suitable where page sized maps were intended.



Machine Scribed Ratio Maps

"Map-makers areobligated to create just as realistic representations of statistical data as they do of the earth's surface."¹ "Statistics must be allowed to speak for themselves. Symbolizations must be geared to ratios of importance and location on the map. The map-maker, unlike the artist, is not granted complete freedom of expression."² Jenks and Knos discussed the psychological impact of shading from light to dark and apply various prescriptions offering criticisms of each.³ Obviously the map maker has a considerable responsibility if his work is to represent the realities of the situation. To do this, the statistics must not be unduly manipulated.

There seems a genuine case for suggesting that different map users might wish to draw their own conclusions from raw machine scribed number maps. The parish or grouped parish map of Scotland provides an ideal base for entering raw ratio data. The jigsaw puzzle shape of many of the parishes is a response to local physical patterns and fairly sharply localized concentrations of similar values may be seen when percentages of the class desired are entered in the centre of each.

The raw statistical data are stored ideally in a data bank and drawn upon to provide computed percentage ratios which the computer scribe would enter on the prepared maps where the centre point of the parishes was pre-determined. This map is then available to the user in the

1. See page 26 in Jenks, G.F., Generalization in Statistical Mapping, AAAG 1963, 53(1) pp.15-26

2. Quoted from page 316 of Jenks, G.F., and Knos, D.S., The Use of Shading Patterns in Graded Series, AAAG 1961 51(3) pp.316-34

3. Jenks and Knos 1961 op cit pp.321-2

same or related field for analysis. Since machine scribed ratio maps do not have a built-in pre-digested pattern,¹ the preparation of the statistical data for calculation is relatively simple. The ratio maps could be updated very easily by altering part of the original program tape or cards. There seems a definite need for ratio maps which may be used and shaded according to the definitions of the user,² who may require a somewhat different scale interval or have other specifications than the ones commonly supplied.

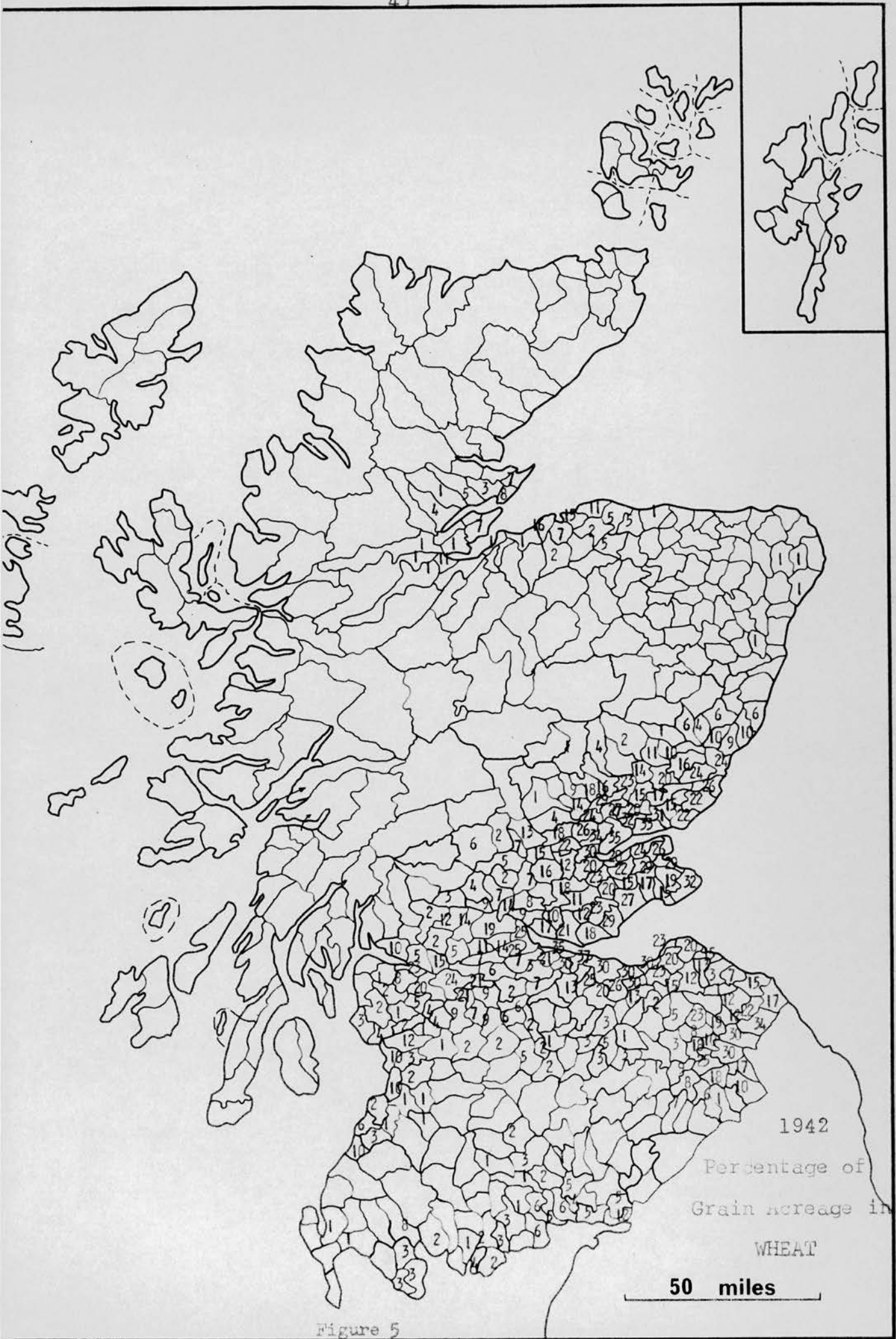
Examples of such maps are provided in Figures 5 and 6. There are strong regional patterns in Scotland which make even these unfinished ratio maps appear useful.

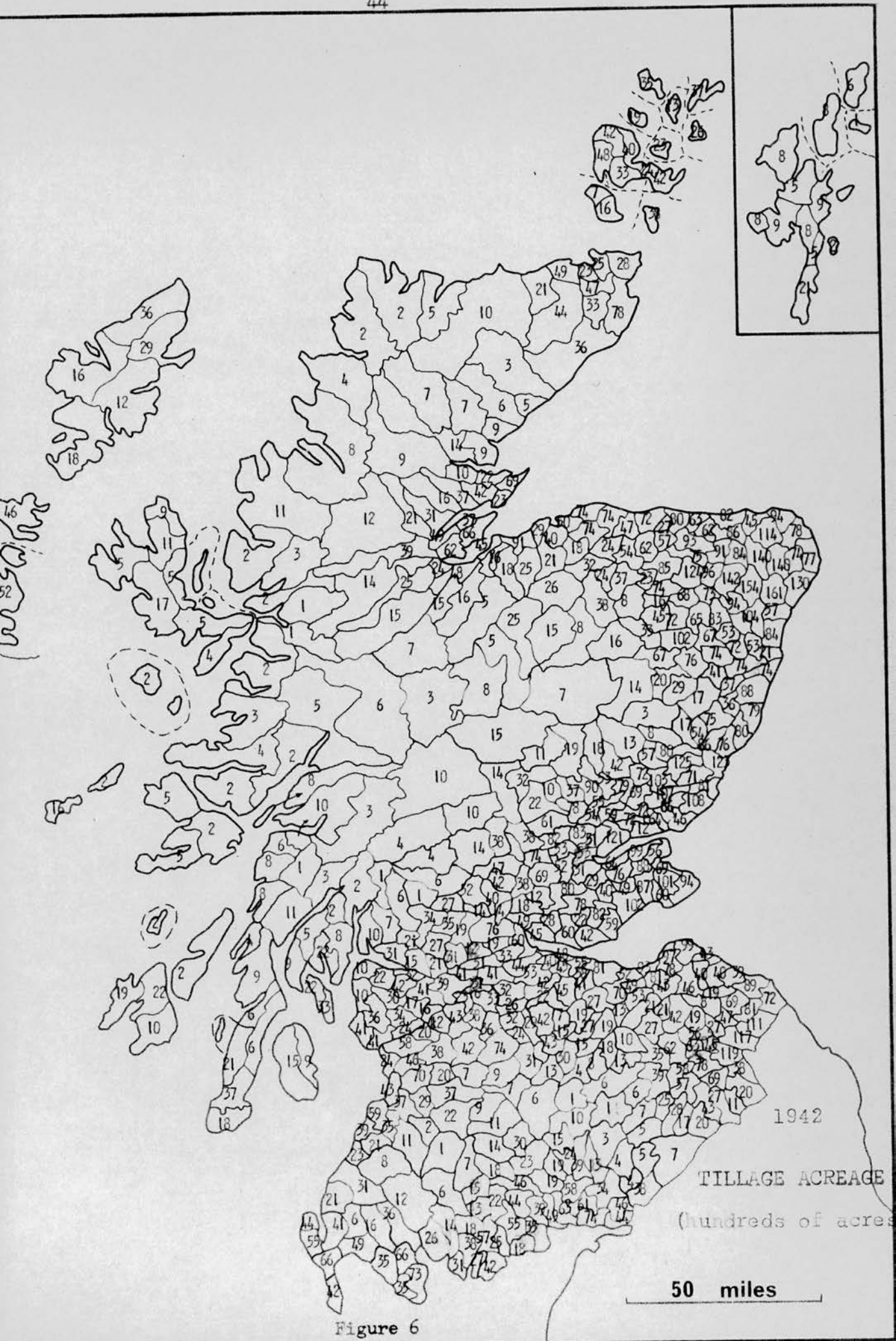
Density Shaded Maps

Any form of density or choropleth map has the drawback of dealing with just one subject at a single year at a time, and offering a static picture. They do not relate well to other subjects which may be important concurrently such as wheat, barley and oats growing in the same area. However, where a great number are offered, providing pictures at a number of years on one page at a

1. One type of pattern is described by Monmonier, M.S., *The Production of Shaded Maps on the Digital Computer*, *The Professional Geographer*, 1965, 17(5) pp. 13-14, but this method is not intended at this point.

2. Such a need was expressed by Meiklejohn, A.K.M., Deputy to the Provincial Director, and others at the Edinburgh and East of Scotland College of Agriculture in personal conversations on September 29, 1967.





time, such maps are useful. Although still dealing exclusively with one subject, a dynamic aspect in depth has been added. The statistics have been grouped and generalized so that the data is not retrievable and wheat maps may not be compared with those for other grains. Nevertheless density shaded maps supply a needed dimension and a large number have been prepared covering peak, trough and more average crop year patterns discovered. Some are used in the methodology section as examples. All are presented in the distribution and patterns section.

Scale Interval

The selection of ideal scale intervals ¹ has been the preoccupation of many researchers in the past two decades or more. A great deal of experiment has been carried out using different intervals ² to deal with the same data, to ascertain the most revealing scale, the best fit and the easiest readability. Robinson ³ encouraged the use of arithmetic isarithmic intervals but geometric, logarithmic, reciprocal and other interval patterns may be used. To test for the best fit Mackay ⁴ has experimented with cumulative or frequency graphs and clinographs. Such techniques are

1. A refreshing discussion on scale interval and the number of classes to be presented is provided by Board, C., on pages 692-4 in Chapter 16, *Maps as Models*, in Chorley, R. J., and Haggett, P., *Models in Geography*, Methuen, London, 1967.

2. Jenks, G. F., and Coulson, M. R. C., *Class Intervals for Statistical Maps*, *The International Yearbook of Cartography* 3, (1963) pp. 119-134.

3. Robinson, A. H., *The Cartographic Representation of the Statistical Surface*, *International Yearbook of Cartography* 1, (1961), pp. 53-63.

4. Mackay, J. R., *An Analysis of Isopleth and Choropleth Class Intervals*, *Economic Geography* 31, (1955), pp. 71-81.

used to show the groupings in each area and the fairness of the interval. However where the landscape features are as bold as in Scotland they superimpose their own strong pattern and dominate all other patterns on any type of map.¹ The map maker is then obliged to follow the stressed patterns and attempt to make the contrasts between the highland and lowland areas as accurate as possible without allowing any scale noise² to interfere.

"As a general rule, isopleth intervals should be chosen to avoid excessive numbers of isolated 'islands' of highs and lows and should coincide with rapid, rather than gradual changes in distribution. An isopleth is usually best employed to separate regions of diversity instead of near uniformity."³ To avoid such a blocky "island" effect, scale interval has been selected using frequency graphs. Care was taken that the chosen scale interval did not allow quite small differences in adjacent areas to be put into different categories and as much as possible the intervals correspond to major gaps in the frequency of distribution of values. Regular interval patterns are preferred and once established were maintained for the same subject throughout the century. It is impossible to use the same scale

1. Most of the experiments done on scale interval have been in the very uniform Midwest of the United States, where different intervals may imply totally different patterns of distribution on the ground.

2. Abrupt changes in scale value or scale noise, was referred to by Alexander, J.W., and Zahorchak, G.A., in Population Density Maps of the United States; Techniques and Patterns, The Geographical Review, 33 (1943) pp. 457-466.

3. See page 8 in Mackay, J.R., Some Problems and Techniques in Isopleth Mapping, Economic Geography 27(1) January 1951 pp. 1-9

interval for every subject ie. wheat, barley, oats, total grain and so on.

A poor pattern of shading can be most misleading.¹ A graded series of fine horizontal dots, dashes and lines leading to top density value in crossed lines, has been preferred. Slanted lines or lines of too many thickness variations introduce patterns which deflect the eye. However Booth has stated that "...a visual effect which is sufficiently understandable to evoke the same response from all viewers is an elusive ideal indeed" and rightly claims that the "conceptual content is the basic substance of the map."²

Percentage Data

Throughout the century the individual grain crops were related to their total and the total grain acreage to the total acreage of crops and grass. This approach was taken in order to preserve the identity of small acreages of wheat and barley³ which are grown in the large highland-upland areas which are not well suited to grain. A preferable method would have been to relate the individual grains directly to a more constant factor within the parish such as arable, tillage or even crops and

1. In separate papers Mather and Thrower offer a discussion on this and comment on patterns which deflect the eye rather than lead it from least to densest regions. See pages 177-9 in Mather, E., A Linear-Distance Map of Farm Population in the United States, AAAG 34(1964)pp.173-180 and Thrower, N.J.W., Relationship and Discordancy in Cartography, International Yearbook of Cartography, 6(1966)pp.13-23.

2. See page 201 in Booth, C.W., Maps and Their Conceptual Content Canadian Geographer, VII(4)1963 pp.201-3.

3. Very small acreages per parish, usually less than 10 acres, are referred to as traces. On the number pattern maps, wheat and barley acreages are often so small they are entered as t. On the percentage basis t is less than 0.5 per cent of the total land in grain.

grass acreage. Even if all of these categories had been consistently available, the very small acreages of wheat and barley would have been expressed in too insignificantly small percentages to enter on the cross-sectional line graphs or on the maps. The fact that a few acres of wheat or barley may be grown even in marginal areas is useful since it reveals information about the success of new grain varieties in overcoming climatic and other limitations. It also reveals that the depopulation of the highland-uplands has led to a loss of the small near-garden patches of wheat and barley which were grown up to 1875 and increasingly rarely thereafter.

The maps based on percentage data have been carefully analyzed before shading but even so anomalies are smoothed over by percentering. Near the highland edge in northern and western Aberdeen, several adjacent parishes may have 99 per cent of their grain area in oats but the 99 per cent refers to real acreages which vary from tens to thousands. In the Southern Uplands, Tweedsmuir Parish reported no grain in 1965 and 1966 but reported 12 acres in 1963 and 8 acres in 1964. On the percentage map, oats then occupied 100 per cent of the grain area yet only 12 acres in one year and 8 acres in another were concerned. In Lochgoilhead Parish, Argyll, one acre of oats was 100 per cent in 1966.

Misleading shifts in emphasis from one grain to another may be achieved by altering a very few acres of crop on the ground in a parish in marginal grain growing areas. At the same time a shift of one per cent may be ignored in more

arable parishes where the change may involve hundreds of acres. The percentage of oats map for 1966 (Figure 7) shows what appears to be a very heavy concentration of oat growing in the highland-upland regions. In fact arable Aberdeen produces far more oats than all of the highland-upland islands area combined. Many of these facts are well known to the student of Scottish affairs but they prove embarrassing to analysts from even closely neighbouring parts of the same nation.

Actual Acreage Data

Maps based on real acreages may provide a more useful order of reality than percentages in countries with sharply varying abilities to produce. In order to study the patterns side by side a number of recent years were mapped on both a percentage data basis and an actual acreage data basis. These are presented together for comparison (Figure 8). Where actual acreages are used the oat pattern maps are altered drastically, to conform to reality. The same or similar results are achievable by relating oats acreages to categories such as tillage, arable or crops and grass acreage. Actual acreage data is not as widely used as percentage data possibly because it may appear too simple an approach. However, a careful comparison of detail reveals that there is a strong case for using both forms of data as a check on patterns established by the one at a time.

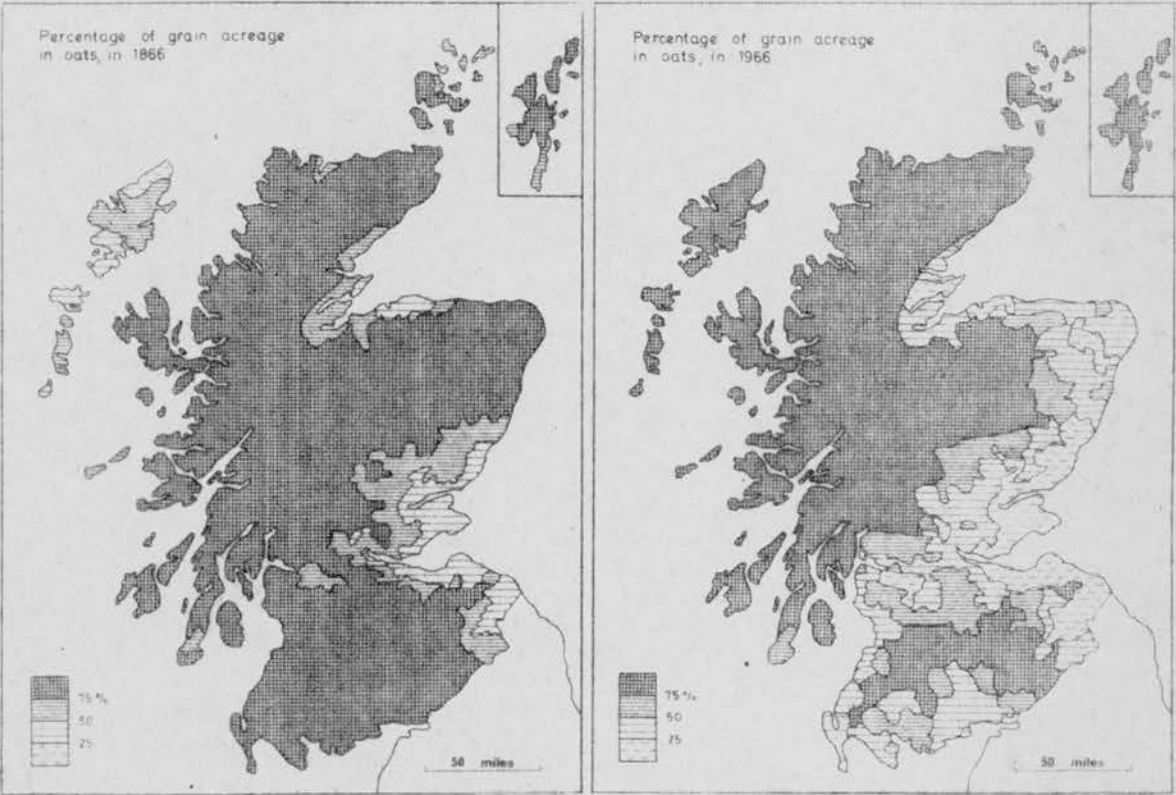


Figure 7

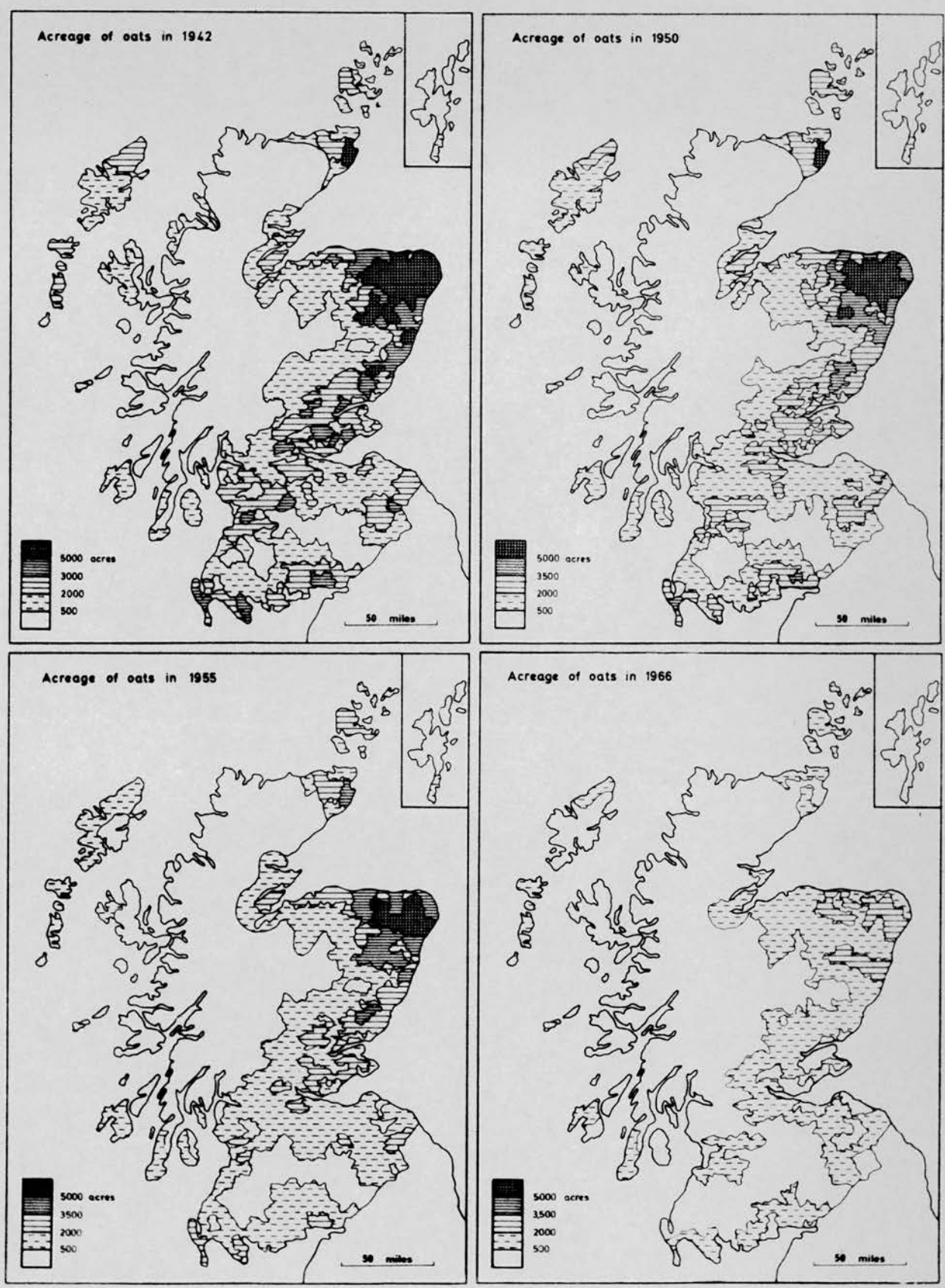


Figure 8



Change Maps

Density shaded maps have been prepared to show percentage change and real acreage change between the peak and trough years and certain more average years, as established on the line graph cross-sections from 1867-1966. They are based on overall change since the discovery that cumulative change offered rather little added pattern in a country where the really suitable arable areas are so confined and limited and occupied almost to their fullest extent over a good deal of the century (Figure 9). Small changes of up to two or slightly more per cent may often be explained by the use of the different fields by the farmer as he follows his usual rotation pattern around the fields at his disposal. Scale intervals have been chosen to segregate areas of low values and of very high values. Only fairly large overall changes proved significant as tests of a true change in vogue from one grain to another. Such changes were usually the result of government intervention or the demands of a wartime economy or the discovery of a new market outlet abroad. Real acreage change maps again serve as a check on the accuracy of assessment provided by maps based on percentage data (Figure 10).

Conclusion

Density shaded maps present a static or limited change picture referring to a single activity or subject at one time, and ignoring the concurrent activity expressed in adjacent subjects, in this case grain crops. The maps

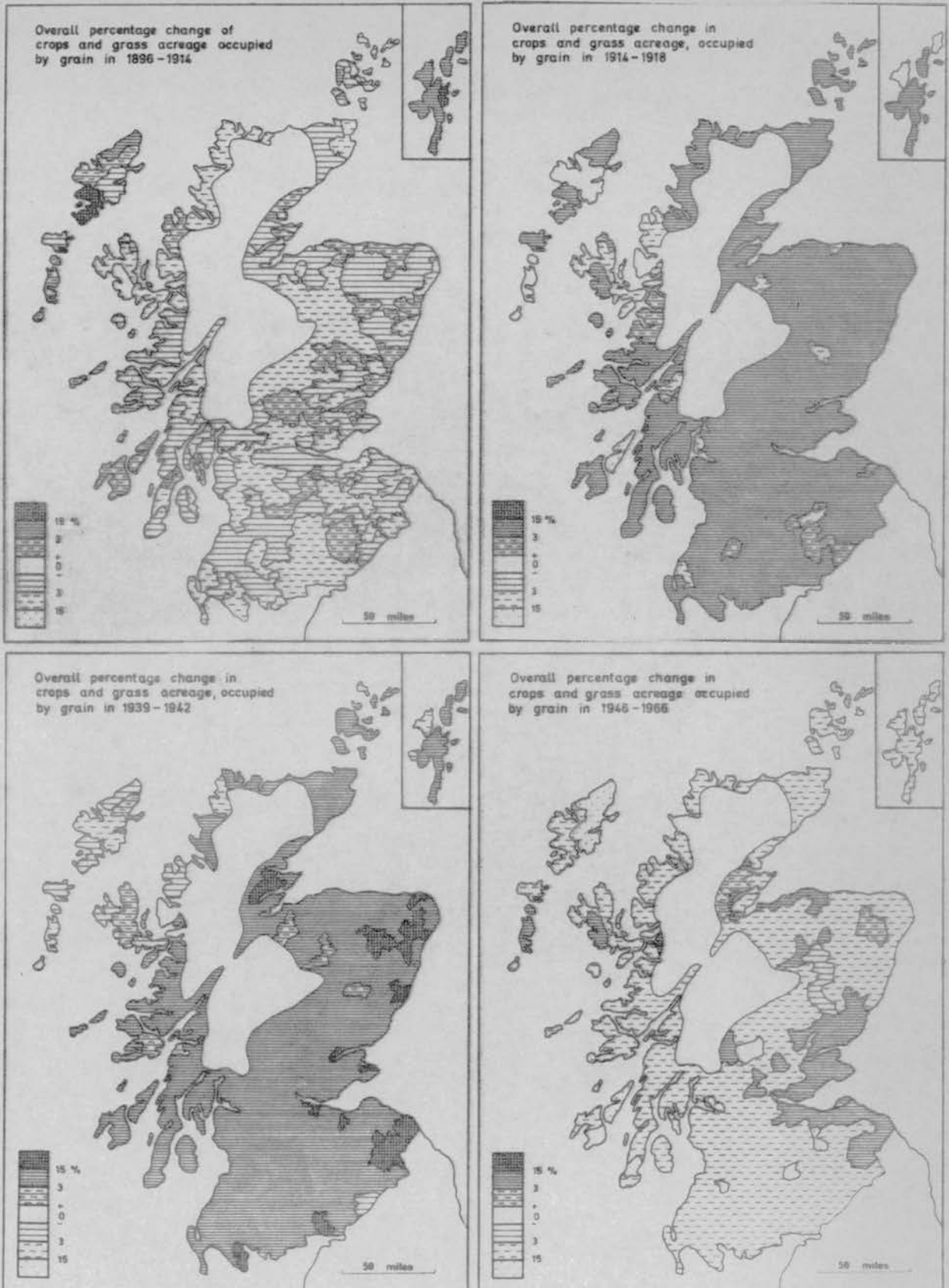


Figure 9

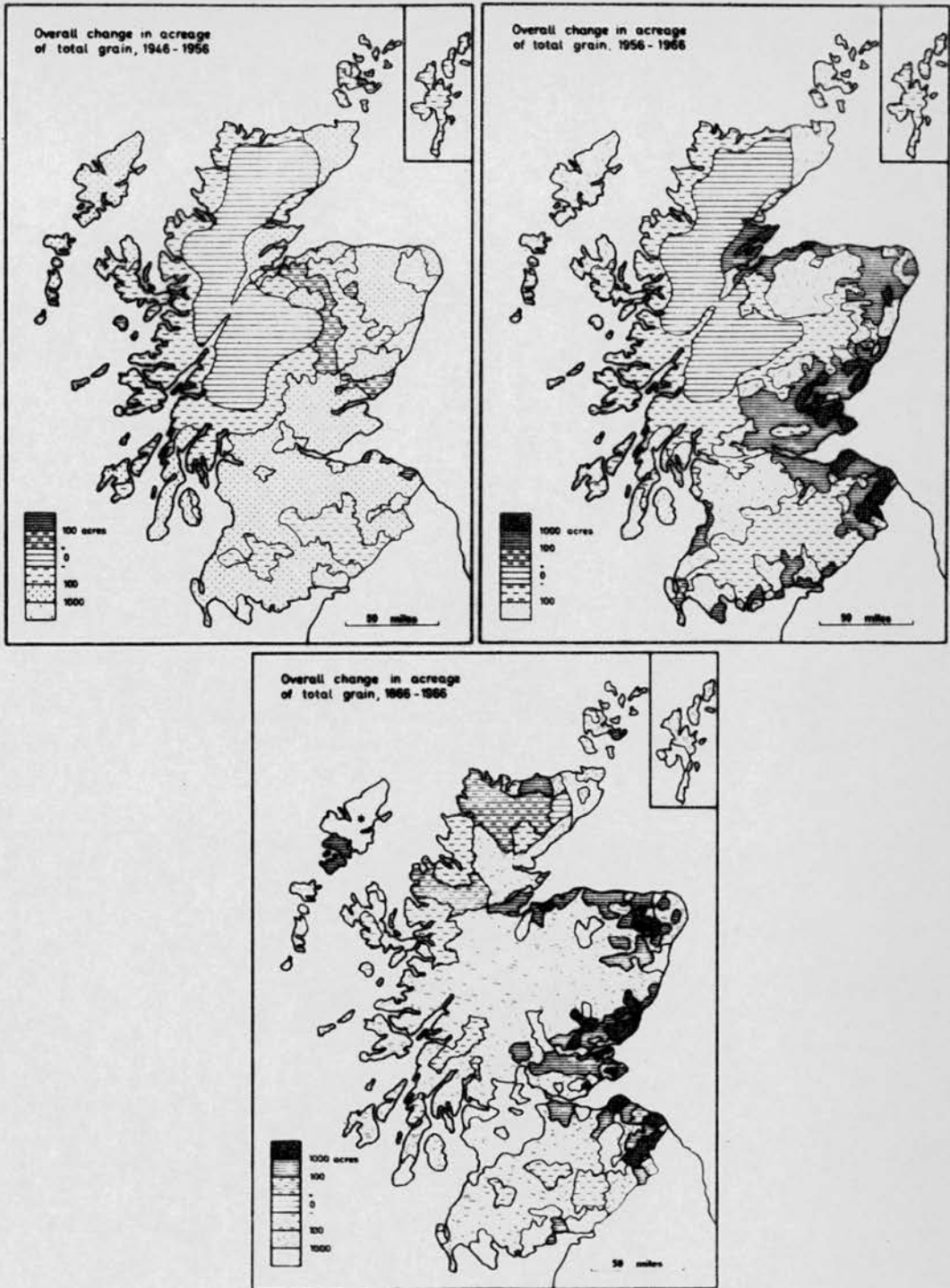


Figure 10

are exclusive and little is to be gained by attempting to compare wheat, barley and oats and other distribution maps at the same time. The data is not retrievable. Comparisons are difficult unless confined on the one hand to highland-upland districts and on the other to lowland ones. However carefully shaded ratio or density maps provide a generalized quantitative measure of the distributions which is easily understood. When scale intervals are well chosen, areas which have the most in common are smoothly linked together. Such maps clearly show that statistical administrative units are their base.

Isoline Maps

Isoline maps are readily prepared either from the percentage ratio or actual acreage machine or hand scribed parish maps of Scotland. The term isoline is used since it is simple and refers to all lines on a map indicating constant values.¹ Mackay has warned that alternative and erroneous interpretations of the data may occur when attempting to draw isoline maps but adds that an intimate knowledge of the topography averts the problem.² He has suggested that even uniform somewhat featureless surfaces, as in part of the Canadian Prairies, are far less likely to be misinterpreted if centrepoin information is placed in hexagonal rather than in triangular or rectangular patterns. In fact the very

¹.A useful discussion on terms is offered by Wright, J.K., *The Terminology of Certain Map Symbols*, *Geographical Review* XXXIV (1944) pp. 653-654.

².See Mackay, J.R., *The Alternative Choice in Isopleth Interpolation*, *The Professional Geographer*, 5(4)1953 pp. 2-4.

irregular lowland parishes of Scotland are more closely agreeable to the hexagonal than any regular blocky pattern.

"Closeness of fit is in large part a matter of judgement in the sense that the investigator, knowing the factors that influence the values of the variables, will apply this knowledge in making decisions as to the location of a single isarithm or group of isarithms."¹

"The average dot map can be conceived of only as a two dimensional representation of a two dimensional distribution because the data represented are individual or small groups of individual phenomena which are located on the map by geographic co-ordinates. A contour map on the other hand, must be conceived of as a two dimensional representation of a three dimensional phenomenon, since there is a vertical as well as horizontal variation."²

Alexander has used both dot and contour symbols on the same maps.³ Imhof provides a demonstration for turning a dot map into isolines and finally into a density shaded map.⁴

Conclusion

In Scotland taken as a whole, the isoline map has certain advantages but a number of drawbacks as well. On

1. See page 289 in Blumenstock, D. I., *The Reliability Factor in the Drawing of Isarithms*, AAAG 43(4) 1953 pp. 289-304.

2. This succinct statement was made by Jenks, G. F., in *Generalization in Statistical Mapping*, AAAG 53(1) 1963 pp. 15-26, on pages 15 and 16.

3. See Alexander, J. W., *An Isarithmic-dot Population Map*, *Economic Geography*, 19(1943) pp. 431-432.

4. Note figures 23, 24 and 25 on page 90 in Imhof, E., *Isolinienkarten*, *International Yearbook of Cartography* 1(1961) pp. 64-98.

the positive side ,isoline maps are much more starkly clear than density shaded or dot maps and the strong physical imprint ensures against erroneous interpretations. Such maps (Figure 11)give valuable ideas as to the centre of concentration,be it acreages of barley or of rough grazing, and they are admirably suited to Scotland. On the negative side, isoline maps of Scotland are probably the most ruthlessly predictable of all and critics may say that they could have drawn them without all the bother of the research. Isolines joining areas of equal crop acreages are bound to cluster in the eastern lowland coastal areas. If they are used for the rough grazing category the cluster pattern is in the highland-uplands and islands. Isoline maps are not easily prepared if the data values present too much pattern in blocks. There is little to be gained from joining up these separate blocks to form a smooth line around a core of concentration and less to be gained by ignoring them as they then become unexplained anomalies. If the scale intervals are carefully chosen, isoline maps provide a useful tool with a good deal of comparative value and some very generalized data patterns may be retrieved. They are not useful for showing the concentration of more than one crop or category at one time. Isoline maps are not applicable in certain years where the patterns break up into regional blocks. They are excellent for mapping tillage,arable,crops and grass,rough grazing and total grain acreage. In short, they are valuable for mapping distributions which do not change markedly for many years.

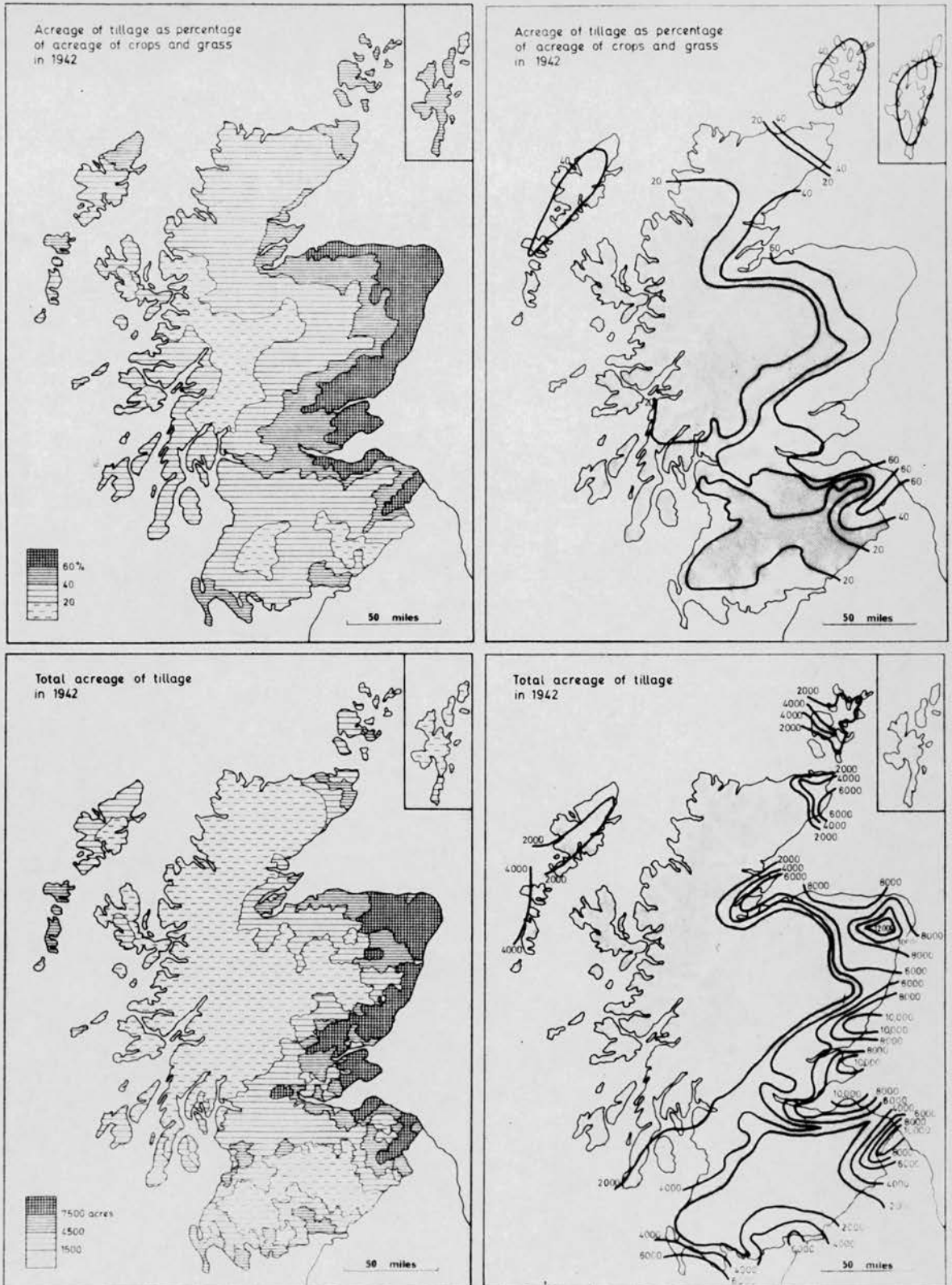


Figure 11

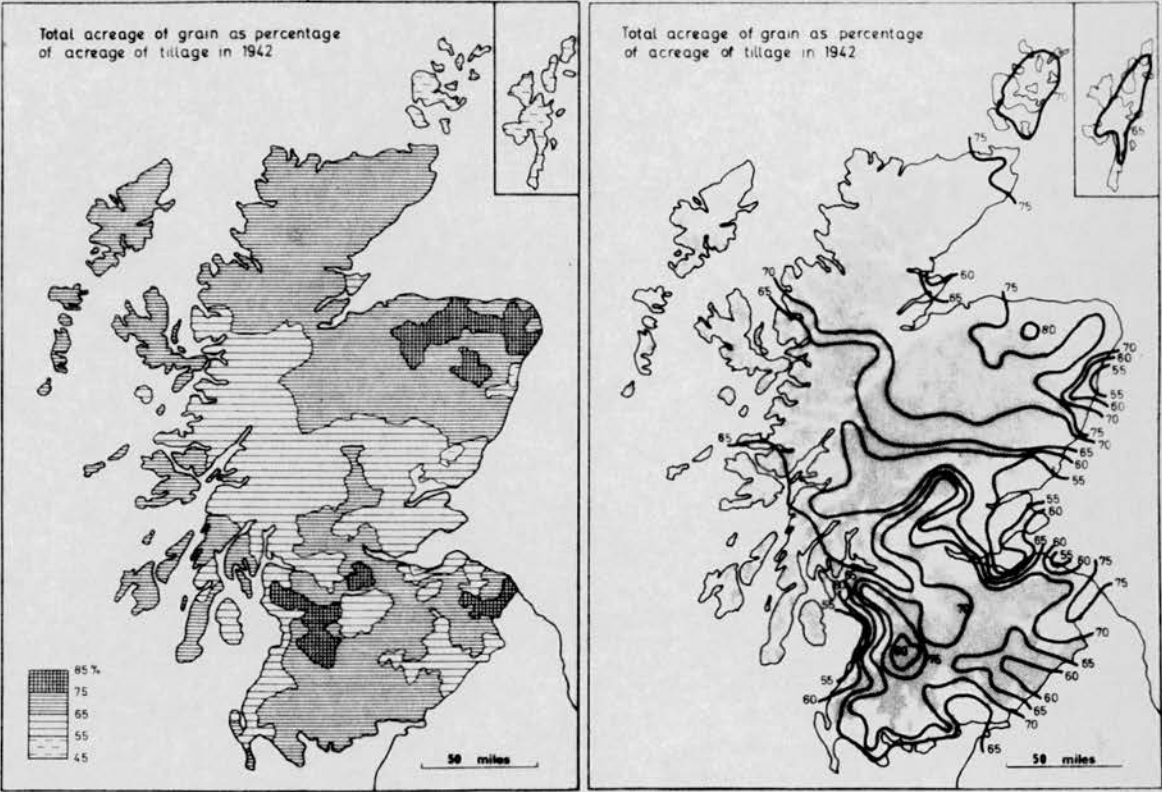


Figure 11

Line Graphs

Line graphs based on percentage were prepared for each of the 54 units of the divided counties and counties from 1867-1966. An early attempt at graphing by the 12 grain regions was abandoned when the unique character of the sub-regions was over-generalized. The graphs show the percentage of the total grain occupied by wheat, barley and oats and the percentage that the grain acreage occupied of total crops and grass acreage. Since both the grain acreages and the total crops and grass acreage declined steadily from 1875 to 1914, a line based on a constant factor was needed to show the real increases or decreases. A base year 1914 was chosen because it came at the end of a lengthy 40 year decline which occurred at the mid-point of the century, and represented a low point in both the main categories (Figure 12).

In the relationship of grain acreage first to real parish crops and grass acreage in the same year and then to the fixed 1914 base acreage, nearly all of the 54 units show a wide disparity in the 1866-1875 period. Presumably in the first five or ten years of the census there were over-estimations of acreages but these were rapidly rectified as a better measure of the field sizes was carried out. Later the two lines came together and often cross and re-cross. This reveals years when the decrease in crops and grass acreage as a whole, went ahead much more rapidly than grain acreage and the reverse. As related previously, there was a need to show small amounts

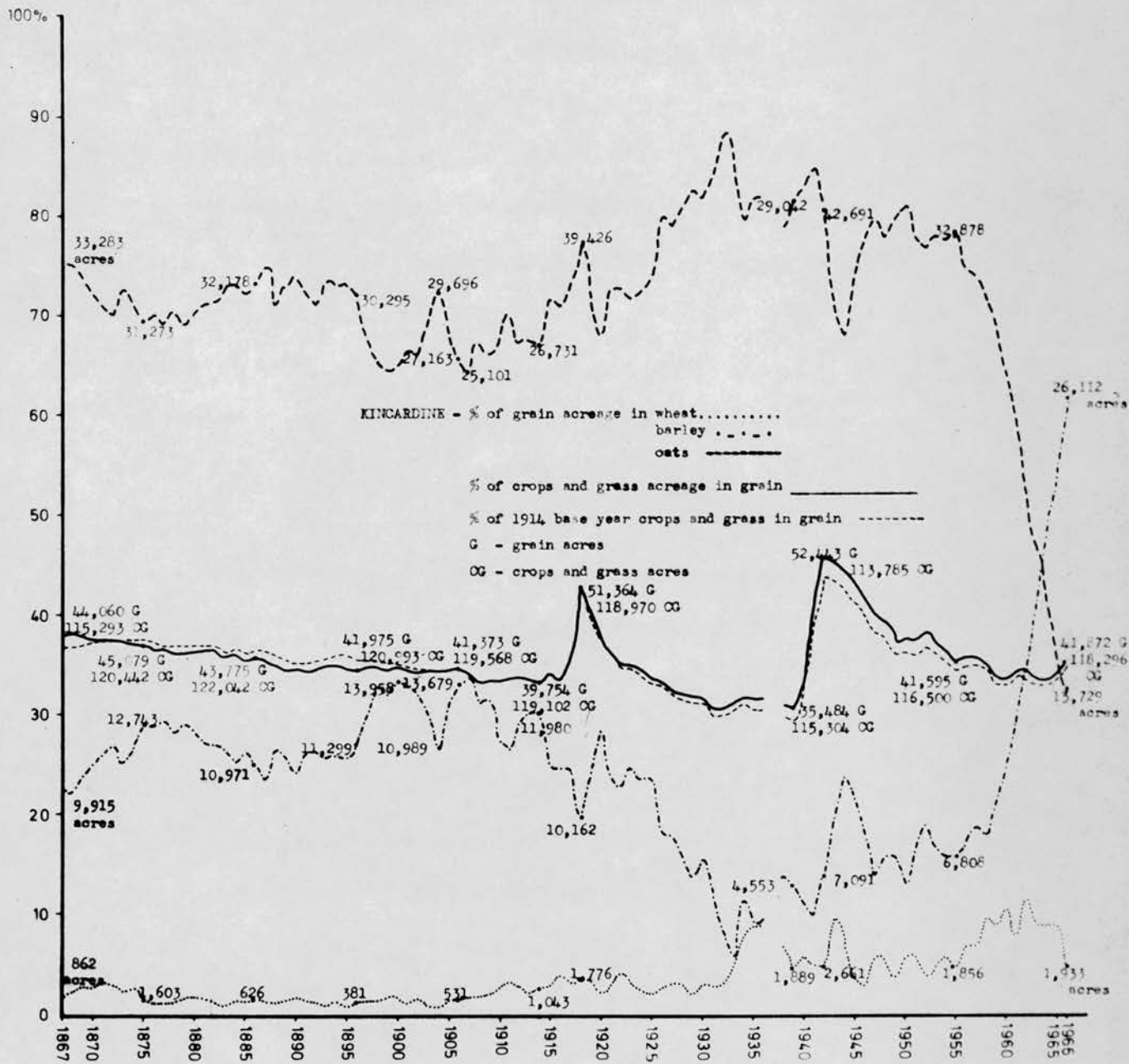


Figure 12

of wheat and barley on the graph and by relating the individual grains to the total grain this was just possible. The result for oats is inflated in appearance¹ in highland-upland areas. The real nature of increases or declines has been shown at intervals along the graph lines by entering the real acreages involved. A preferable solution would have been to relate the individual grain acreages to either tillage or arable acreage, but these categories were seldom supplied officially at the parish level.² Line graphs for the 54 units are found in Appendix C.

Conclusion

Line graphs give a valuable picture in depth for one unit area at a time and have a good multi-component content. They have proven exceptionally useful in locating long range trends over the century. The peak and trough years are sharply depicted and have a good correlation by individual grain crops over divided county and county units in the same general area. Total grain correlations reveal an immediate response to government interventions from time to time and the exigencies of war in the

1. The use of logarithmic graph paper for plotting real acreages was investigated in order to accommodate the large acreages in Aberdeen parishes, but the graphs suffer from visual difficulties. A useful paper on this was written by Dickie, H.F., *The Use of Logarithmic Paper for Plotting Geographical Statistics*, *Geography* 24(1939)pp.126-130.

2. While the notion of what constitutes crops and grass may have quite different connotations when reported by parishes in arable lowlands, it has been accepted as reported. Inconsistent categorization will apply mainly in the rougher areas where field sizes are difficult to estimate and grass quality does not reach the upper values possible in more regularly tilled arable areas. Overestimation of the category in the highland-upland parishes would mean that percentages of grain to crops and grass may be slightly lower than they should be.

counties which are most adaptable to changing crop patterns nearest the larger centres where information is disseminated rapidly. Farther into the interior and to the north, the response is often a year later than in the Forth area. Placed at the appropriate places on a large map, these graphs give a dynamic picture of the grain patterns of Scotland in the century to 1966.

Bar Graph Maps

Various kinds of graphs on maps may be used but divided proportional circles, spheres and cubes do not compare easily,¹ and do not yield up retrievable data unless it is printed on as well. Such symbols do give desirable multi-component representation. Proportional area graphs are preferable since they supply all of the aims and do not suffer from visual distortion.

The regional percentage share of Scotland's grain acreage and output maps have been compiled from census acreages and from yield information supplied from local agricultural officers by counties. Where necessary the estimated bushel per acre yields were converted to hundredweights per acre using standard individual weights.² When attempting to provide an order of magnitude estimate of output for 1867 no nearer estimates were available than those offered for the first time in 1885.³ These were used

1. A useful discussion of comparability is provided by Raisz, E., Block-Pile System of Statistical Maps, Economic Geography 15 (1939) pp. 185-188.

2. Wheat 63, Barley 56, oats 42 pounds per bushel, cwt 112 lbs.

3. The Corn Returns Act 1882 specification for weights were used in this instance. Wheat 60, barley 50 and oats 39 pounds per bushel.

to give a helpful theoretical and fairly representative estimate of the kind of output likely to have been possible in 1867. Some order of magnitude of output is supplied even if many growth factors were different.

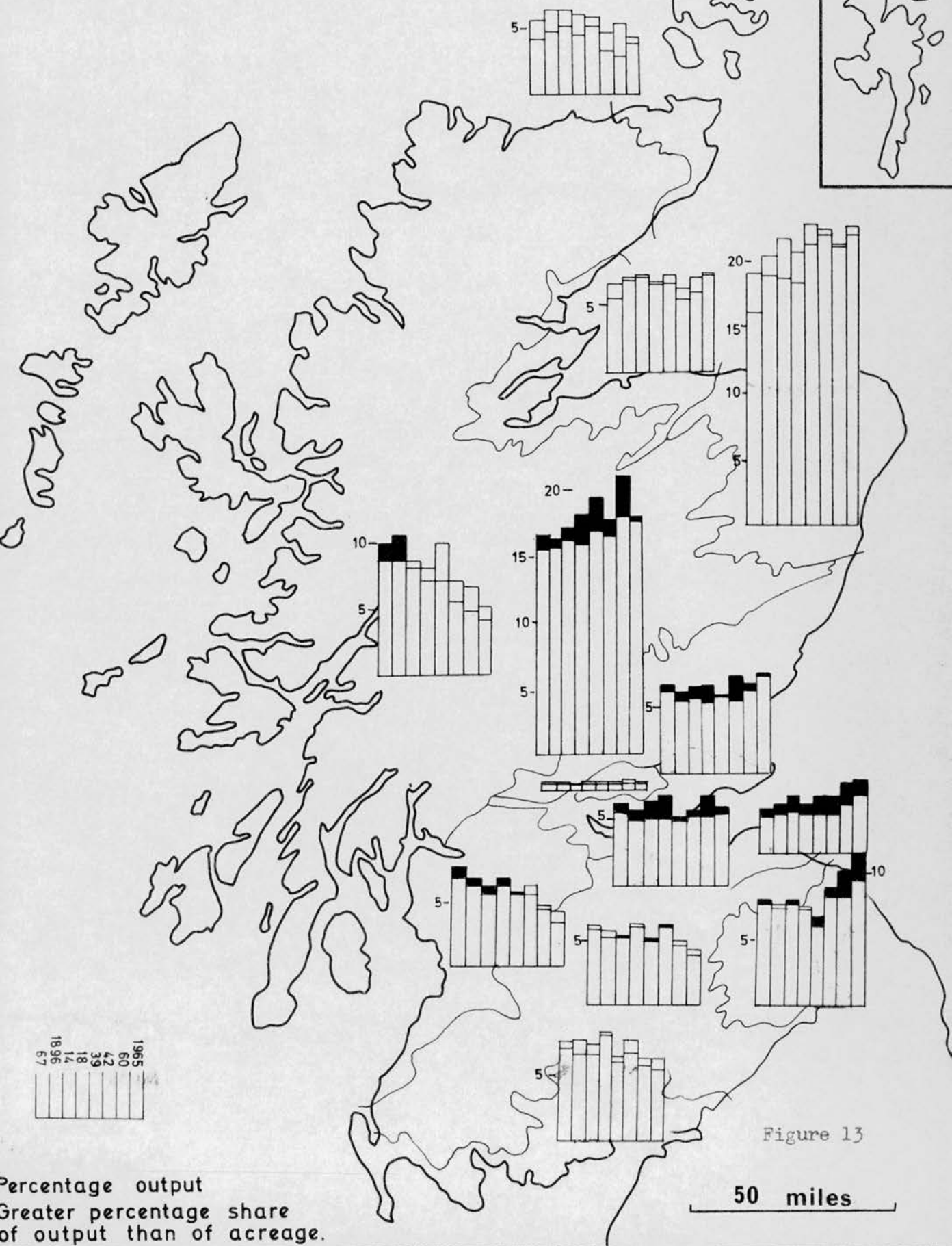
Proportional area bar graphs have been constructed and placed on maps for the years 1867 and 1965¹, for the trough years 1914 and 1939 and peak years 1918 and 1942 and for two other years 1896 and 1960. The overprinting of output on the acreage maps is useful (even though based on estimates) because it shows the relative ability to produce in every area of the country at once. Notably the output in Aberdeen from the largest number of acres devoted to grain in one region, does not rise above the average for the country as a whole and is usually less (Figure 13). In comparison, the production of arable Perth, Angus and Kincardine, and the Lothians is usually higher than the countrywide average. Though output is based on the estimates, it provides a useful parameter completely consistent with the expected and forecastable patterns. Where the bar graph maps show one grain at a time over the eight years selected, they readily define changing regions of importance (Figure 14).

Conclusion

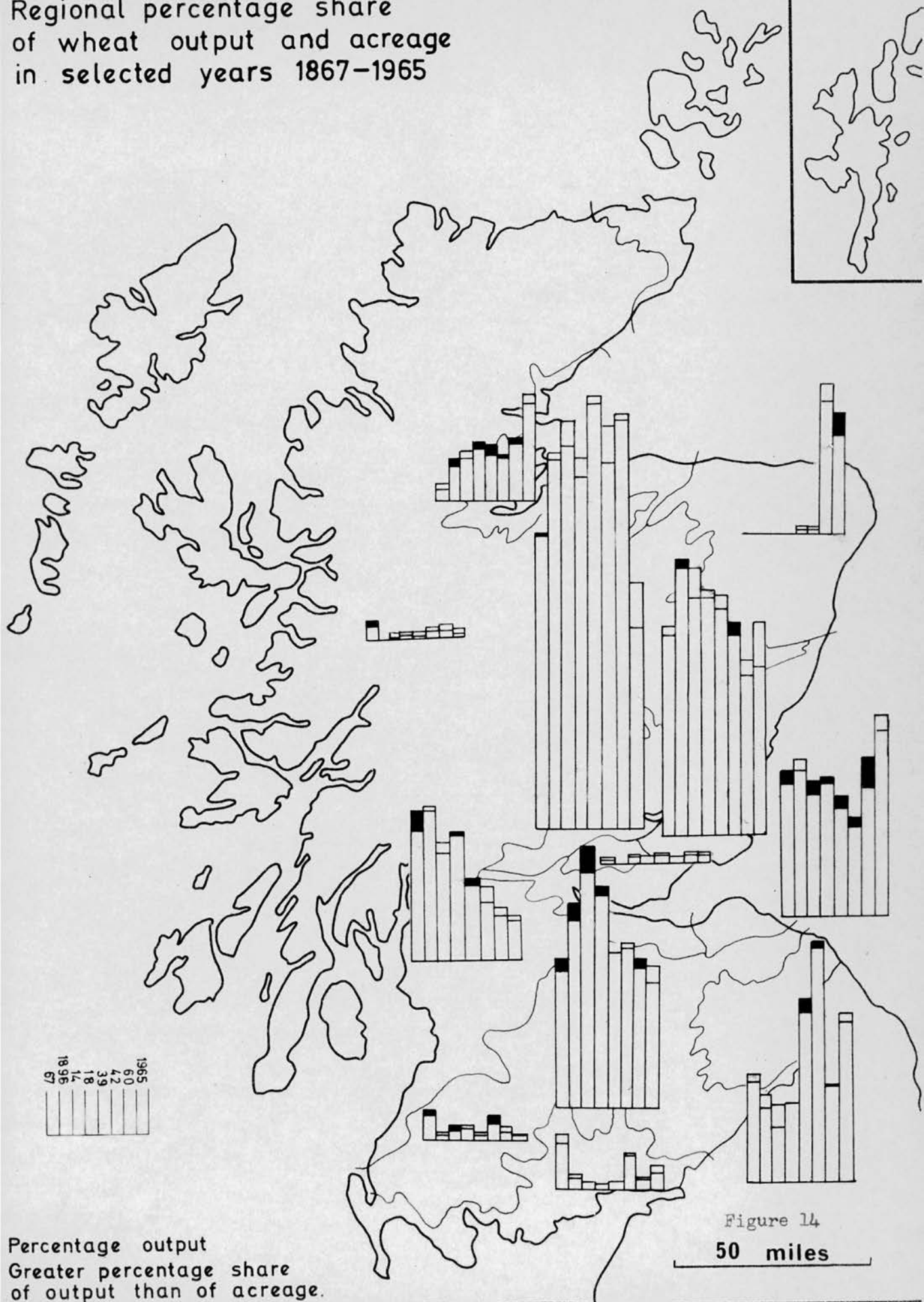
An overall disadvantage is the regional generalization in the highland-uplands islands regions. The output of regions seem disproportionally large and it is not obvious enough that they are made up of parts of many counties which have differing abilities to grow and harvest grain.

1. The last year when yield estimates were made public.

Regional percentage share of grain acreage and output in selected years 1867-1965



Regional percentage share
of wheat output and acreage
in selected years 1867-1965



Also the yield estimates are averaged and one set given per county while it would have been most useful to have some of the spot estimates in each county representing differing conditions and abilities to grow grain. Probably the estimates would have shown higher yields in well favoured long-established arable areas and lower ones in rougher higher areas. The bar graphs on the 54 unit divided county and county map would have been some improvement, rather than the 12 unit regional map, but not at the scale shown. Nevertheless visual comparisons are sharp and even with these drawbacks these maps offer a valuable contribution to a multi-component and multi-dimensional picture.

Ranking

"Individual crops, like the individual systematic elements of geography, are commonly studied by and for themselves alone. Just as the definition and interpretation of a geographic pattern of soils without reference to vegetation, or of soils or vegetation without reference to climate, constitute only a partial structure of integrated understanding, so also observations concerning one particular crop without reference to its immediate cultivated companions can illuminate no more than a limited segment of the broad mosaic of cropland use. Only rarely does a crop assume a position approximating isolation."¹ Here the approach has been restricted to patterns resulting from plotting grain rank order by

1. See page 175 in Weaver, J.C., Crop-Combination Regions in the Middle West, The Geographical Review, 44(2) April 1954 pp. 175-200.

parishes to show trends to and from a basic pattern. There are few areas in Scotland so versatile that a variety of crop combinations could be developed. Weaver would have had to consolidate Scotland's three major grain crops into one crop combination region for most of the country. However the view expressed in the quotation is basic and admirable and Weaver has done somewhat similar work involving changing cropland patterns by decades.¹

A century of ranked patterns for Scotland has revealed yet another dimension of changes. While oats still occupy a very large acreage, it is clear that the efforts of the plant breeders in providing new grain varieties have made startling changes in the ability to grow grain. Areas which had a long fixed pattern based mostly on oat growing with a small amount of barley and some wheat, are not able to switch their program to suit the economic demands of the times. Despite the new developments in grain breeding, oats are still the premier crop in the whole of Scotland, if not always regionally or sub-regionally.

Eight patterns were noticeable throughout the major part of the century and in the last decade a ninth has appeared in two cropping areas where the usual order has been fairly recently reversed. The basic pattern(if it may be so termed) is that of oats, in those areas where

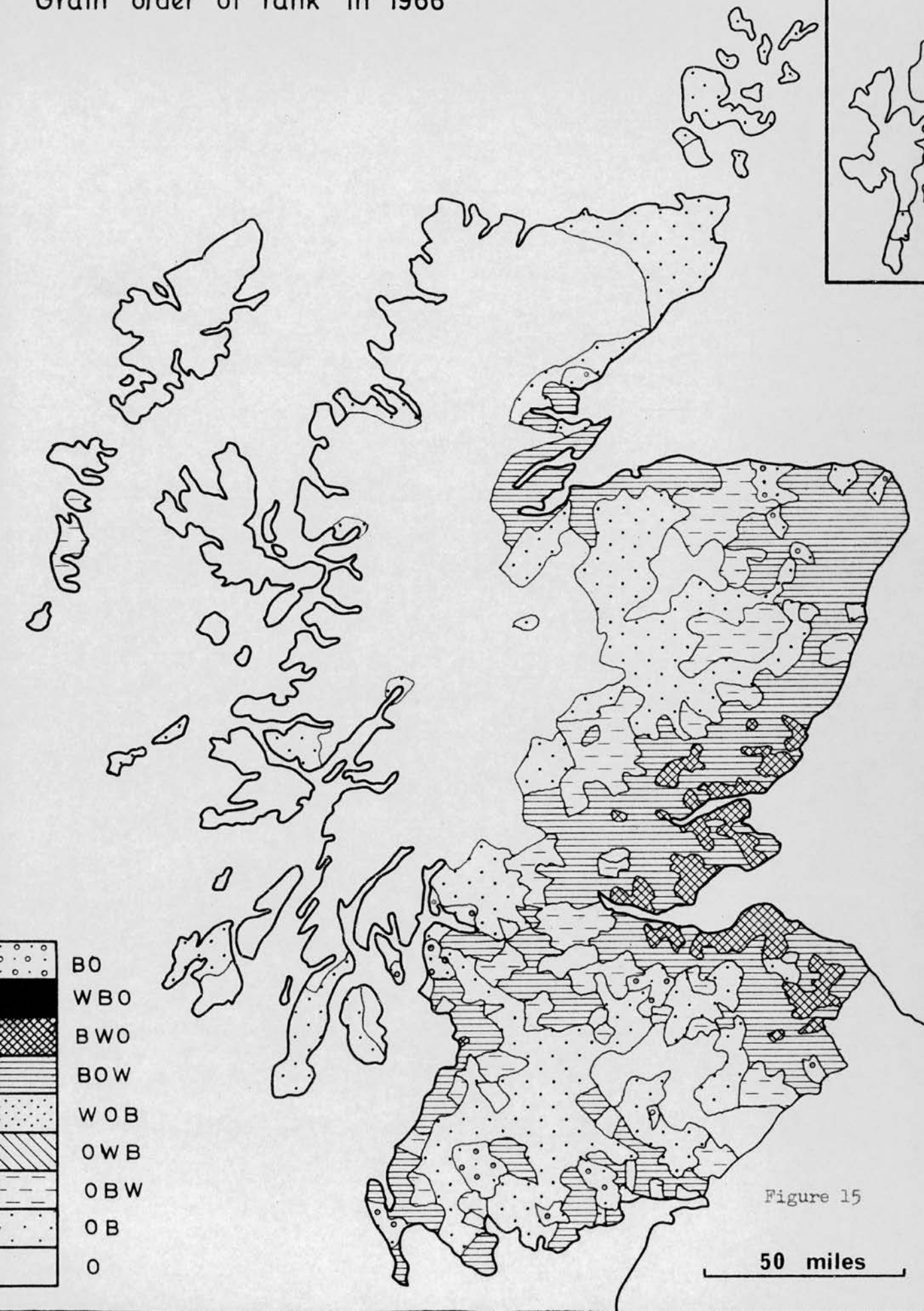
¹Weaver, J.C., Changing Patterns of Cropland Use in the Middle West, Economic Geography, 30(1) January 1954 pp.1-47. On a detailed county basis such as in East Lothian, more than one crop combination should be possible.

it is the hardest and most suited grain for a diversity of difficult growing conditions. In 1866, this single crop pattern extended through the heart of the Southern Uplands, in much of Argyll and in western Ross and Cromarty. In 1966, the single crop area has widened considerably in the highlands. This reflects a century of continued change and consolidation in the highlands and a sizeable outflow of the farming population leaving scattered acreages of tilled land to return to grass.

An even more common pattern is that where the order is oats followed by barley. The position of barley is considerably less important than oats and in most cases OB areas up to 1964, refer to acreages from a trace (usually less than 10) to more than 50 per parish. After 1964 the newer varieties of barley have led to substitution of barley in more and more areas formerly devoted to oats along with a green or root crop or grass (Figure 15).

A very common rank order is that of oats, barley and wheat (OBW). The position of the barley and wheat as second and third is misleading since together they usually made up less than 10 per cent of the first in the rank, except in war effort years and in the last ten years. Wheat, oats and barley (WOB) is a most unusual and rare rank and usually represented in a short period of changeover to other ranks. Even during the peak wheat production after the Corn Production Act 1917, the Wheat Act 1932 and the peak years during the 1939-1945 war, particularly in 1942 and 1943, the rising position of wheat is commonly shown

Grain order of rank in 1966



by an increase in the OWB pattern and not a complete switch to WOB. Wheat growing is severely limited to the very best arable land in the most favourable climate in Scotland.

Wheat, barley and oats (WBO) is another rare rank order which developed between 1938 and 1941 in Berwick and Roxburgh and in one parish in Midlothian. The pattern had been a feature in seven parishes in Midlothian, East Lothian and Fife in 1866 and for a few years thereafter. Following the minor peak in barley acreages in south-eastern Scotland in 1921, there was a long period when barley acreages fell to less than a third of oat acreages in Berwick and Roxburgh. An alternative crop did not present itself until 1933 in Berwick and 1935 in Roxburgh when spring wheat acreages rose sharply from about 400 acres in each county to over 2200 and 1350 acres respectively. This pattern gradually developed until 1942 when the new rank pattern WBO emerged. Although spring wheat continued to occupy over 1000 acres in each county in the years up to 1953 (when spring wheat was not reported separately) it was not enough to continue the pattern. Since 1953 the total wheat acreage has not increased enough to alter the barley dominated pattern. The emergence of new patterns may be seen in Figure 16.

Barley, oats and wheat (BOW) is recently a very common order of rank. It was confined to a handful of parishes spread among East Lothian, Fife and Roxburgh in 1866 but was well established in those counties and in

Number of parishes involved in grain order of rank changes, 1916-1966

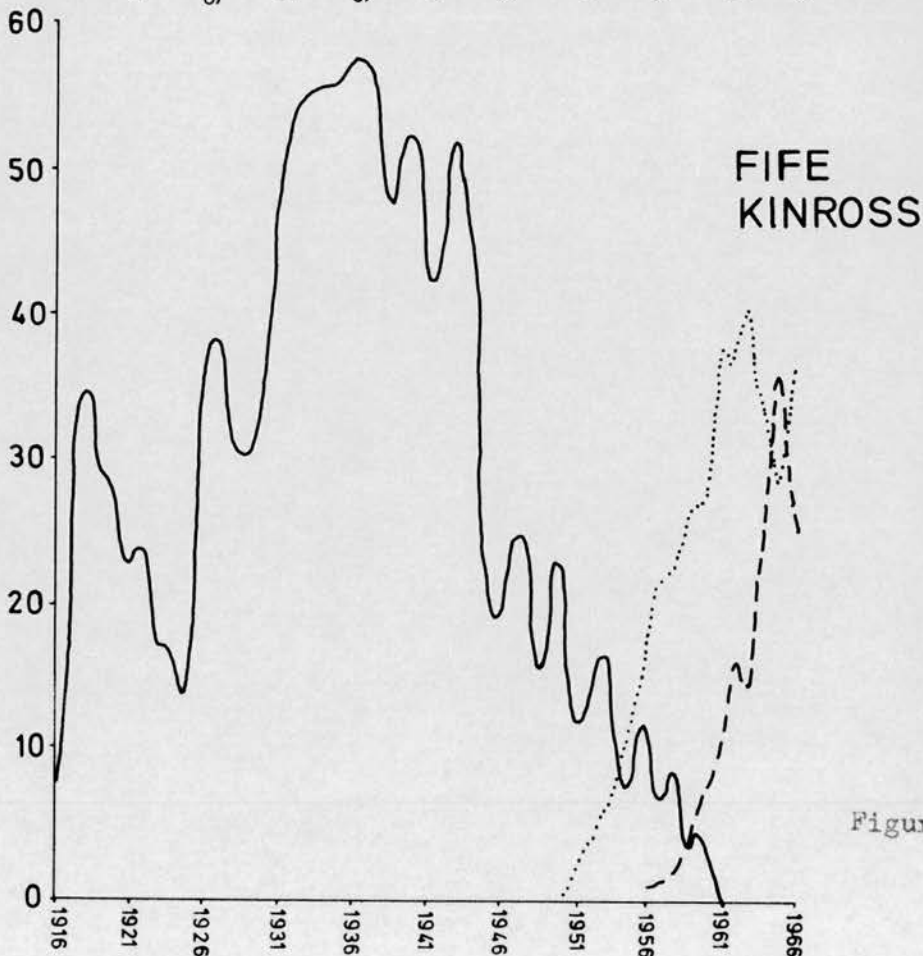
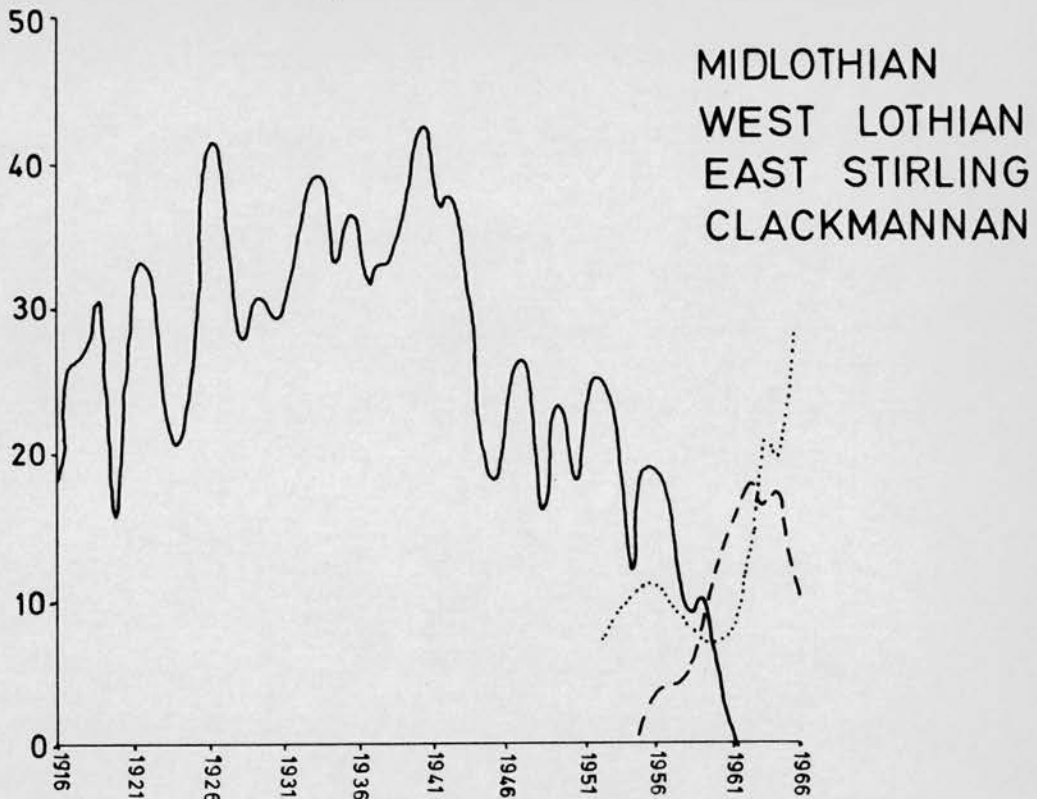


Figure 16

The longterm, older OBW, OB, O patterns are omitted

BOW BWO - - OWB —

Berwick with a start in Midlothian and West Lothian in 1875. East Lothian, Berwick and Roxburgh provided the nucleus for barley-dominated cropping through to 1955 when the area gradually expanded. After 1960 expansion was more rapid, culminating in barley dominated cropping since 1964 in the greater part of the arable lowlands, particularly in the east. While BOW has become the dominant rank order in 1966, the oldest areas of occurrence have changed their order to the even more revealing BWO order. This reflects areas of very good arable land and a minimum of climatic restrictions (concerned mainly with an overabundance of moisture or prevalence of damaging frost). The climatic amelioration might well be cyclical and subject to a change which would make this very versatile cropping pattern impossible and a return to the older more rigid patterns. The BOW and BWO patterns have spread rapidly since new seed varieties have been developed and regional geographic restrictions on their growth eased considerably. The quantity position of barley in relation to the next in order is usually almost as overwhelming as the old oat dominant in relation to next in order, even in northeastern Aberdeen.

In 1965 and 1966 a new rank order developed when parishes bordering on the uplands or in areas of hitherto fairly severe climatic restrictions on the southwest and southern coast, switched from the usual OB pattern to barley oats (BO). The total parishes involved is 40 and the areas are shown on the 1966 grain order map (Figure 15).

The degree of change is clearly presented in the number pattern, graph sections and maps which follow, or in the graph maps which were described previously. When oats is at the head of the rank order, it usually leads all other grains overwhelmingly. In the five years to 1966 when barley emerged as such an important crop, it also leads overwhelmingly over the next grain in order except in parishes approaching the edge of the highland-uplands or in the north and west where the change has been most recent. In the few years and in the small areas when wheat became the dominant grain, it has been closely followed by both second and third in rank order.

Conclusion

Ranking has provided interesting results not at all apparent in other forms of representation. The exercise was confined to ranking in order of precedence with general commentary on the relationship of each grain in the order. The actual acreages involved in the changes are presented in divided county summary form in the number pattern maps and in proportional area form in the section graphs and section graph maps, and in other maps. Ranking adds a valuable new dimension but does not fill all of the prescribed aims. There is a good multi-dimensional quality and good areal comparability on the density maps (the full set of the sample years prepared are used in the patterns section) but retrievability of data is not possible, until comparisons are made with the number pattern maps which follow.

Number Pattern Maps

All of the methods used so far have failed in one or more aspects to provide the desired degree of general retrievability of statistics, unit area comparability and multi-component and multi-dimensional representation of the data. The search for areal comparability¹ has led to the grouping of the 636 more or less lowland parishes into 220 grouped parishes and these improve relationships within the lowland areas although still offering a contrast with the 225 larger parish units in the highland-uplands and islands. The mapping of these grouped parish units has revealed that they might well have been differently organized with a change of map subject, since the parishes have such strong individuality that it is possible to have aspects of highland-upland landscape in the midst of an arable lowland area. Even when using the grouped parishes, it was occasionally necessary to link one or more single parishes into a new grouping to keep common values in one unit. This regrouping² was

¹Robinson was concerned about areal comparability and referred to three states of the same size and identical distributions of x and y over the entire area but within each there were differing sizes of enumeration districts reporting the raw data. See Robinson, A.H., *The Necessity of Weighting Values in Correlation Analysis of Areal Data*, AAAG 46(2)1956 pp.233-236. Curry, L., in a Note on Spatial Associations, *The Professional Geographer*, 2(1)1966 pp.97-99 agrees with Robinson and says on page 98 "It might be better after map study to simply throw-out data for areas over a certain size." Here a partial solution is found by introducing divided units and comparing within rather than across highland-upland and lowland regions.

²See Thomas, E.N., and Anderson, D.L., *Additional Comments on Weighting Values in Correlation Analysis of Areal Data*, AAAG 55(3)1965 pp 492-505, where they reject weighting and suggest statistical manipulation.

resorted to in the margins of arable Aberdeen, Angus and Perth with neighbouring highland parts of the same counties and in the Ochil Hills region with neighbouring parts of Fife. The major problem was to find some way of showing productive areas proportionally to the next area. In the final analysis, the only equitable way to solve the problem of areal differences and comparability in the Scottish parishes is through the use of unit reporting areas of identical size.¹

Before the number patterns were evolved, ratio maps were prepared showing single grain percentages by the 12 grain regions and sub-regions.² A great deal of valuable detail was lost and the averaging in the larger units smoothed out local differences. These maps were then improved by returning the county boundaries to the regional maps and obtaining 54 units. The result was that the large highland-upland region was divided into sections which had attributes of the grain growing in the highland-upland area as well as tendencies toward the patterns prevalent in the more arable areas of the individual counties. However the map still dealt with only one subject at a time. An additional problem was the misleading impression that the ratios referred to the whole size of the

1. Hagerstrand, T., *The Computer and the Geographer*, Institute of British Geographers, Trans. No. 42, December 1967 pp. 1-19, makes this suggestion as did Claeson, C-F., 1960 op cit p. 10.

2. Numerous regional maps of Scotland have been prepared for different purposes. See Snodgrass, C. P., *Map of Economic Regions of Scotland*, *The Scottish Geographical Magazine*, 59(1) April 1943 pp. 14-18.

individual 54 units. While the percentage relationship between grain and crops and grass was 35 in arable lowland Aberdeen and 12 in highland Aberdeen, no hint of the base size referred to was offered. It is grossly misleading to visually compare the two parts of Aberdeen, conclude that the highland part is roughly one third of the lowland part and fall into the dangerous assumption that crops and grass in the one part is roughly one third of that in the other. Some way of making this situation clear was essential.

Since it was possible to separate parishes in the more arable lowland from those in the highland-upland by noting the pattern of cropping between the three major grain crops and the pattern of percentages of crops and grass acreages devoted to grain, a solution to the multi-dimensional, multi-component and comparability aims presented itself. The percentages of total grain occupied by each individual grain, the percentage relationship of all grain to crops and grass acreage and the rounded real figure for crops and grass, in hundreds of acres was written in number patterns on the map. The map used is the one divided into 54 units but for a more intimate view of the situation the parish or grouped parish map may be used and the results presented in a number of map sheets.

Since the small amounts of rye reported is grown chiefly for pasture purposes and less often for the production of seed for sale or for farm use, it is

treated entirely separately. It occupies very small fractions of the total grain output and is grown increasingly rarely and in the more marginal grain areas. Mixed grain is totaled into grain acreage but is not otherwise differentiated. It is most frequently the unexpressed part of 100 per cent in highland and island Inverness. Some small acreages are regularly planted in North and South Uist and in other parishes in the northern and western area. Mixed grain is rare in the arable lowlands.

The input information in the form of percentages of acreage relationships could have been presented in tabular form but much of the spatial impact of the multi-component, multi-dimension and areal comparability factors is lost. "The majority of the statistical agencies of the world present geographical data in the form of lexiconographic listing of areas with associated information. Symbolically the results are usually simply listed in tables which can be meaningfully analyzed directly 'without reference to location' by a variety of methods. A geographical analysis making reference to the location can be undertaken 'only by the addition of supplementary information' and this information is normally supplied by a map which shows the location of the named areas. In map form the information is spatially ordered."¹ Tobler goes on to refer to the ordering of information by areal

¹. See page 203 in Tobler, W.R., Geographical Ordering of Information, Canadian Geographer 7(4)1963 pp.203-205.

grouping in a square or triangle of standard size, commonly basing the centre of the grouping on the centre of the area represented. It was from a study of this paper and another by Tobler¹ that the decision to use number pattern maps was derived.

The input part of the number pattern deals with acreages and is entered on number pattern maps from 1867-1966 within a one centimetre square, Where space is short the square pattern is sometimes adjusted.

An output number pattern has been created for the years 1885-1965 during which time county estimates were regularly reported. In early years from 1884 when the estimated yields per acre were first reported, average weights for a bushel of wheat barley and oats were given for the year at hand. Adverse years featured lighter weights. The average weights were not necessary after the decision to report yield estimates in hundred-weights in the early 1920's. These estimates provided a very valuable attempt at order of magnitude assessment and their consistency has been tested in two sets of graphs by counties and by regions. The yield picture was essential to give a measure of the differing ability to produce grain over the country.² The estimates are used here with the encouragement of agricultural experts.³

1. Tobler, W.R., A Polynomial Representation of Michigan Population, Michigan Academy of Sciences, Arts and Letters Papers, Vol. XLIX 1964.

2. See page 40 in Scola, P.W., and Catt, D.C., Yields, Stocks on Farms and Disposals of Cereals in Scotland, Scottish Agricultural Economics 16 (1966) pp. 39-41.

3. Meiklejohn, A.K.M., Deputy to the Provincial Director and others in the College of Agriculture, Edinburgh, Autumn 1967.

It is understood that yield data gives a useful estimated and not actual order of magnitude.¹ The publishing of official estimates ceased in 1965.

In the first line of the output section of the number pattern, the estimated hundredweight yields are entered per acre of wheat, barley and oats. On the second line the output in hundreds of tons is entered by grains in the same order. The second figure has been obtained by totalling the acreage of each grain by the 54 unit divided county and county system and multiplying by the estimated output in hundredweights and converting the results into hundreds of tons. The rounding of the figures completed the operation.

The completed number pattern takes the following form:

| | | |
|--------|------------|---|
| | 3 36 61 | - % wheat, barley, oats to total grain |
| INPUT | 25 898 | - % grain to crops and grass and 100's of acres of crops and grass |
| | 18 17 15 | - yield per acre in cwts. |
| OUTPUT | 30 117 214 | - output in hundreds of tons |

Because of the estimated order of magnitude nature of the the output part of the number pattern, it is presented on

1. A detailed analysis of yield forecasts in the 1885-1925 period was done by Venn, J.A., in *The Foundations of Agricultural Economics*, Cambridge University Press, 2nd edition, 1933, in Chapter 21 on Crop Estimating and Forecasting, pp. 449-469. In the four successive decades Venn found that the Scottish yield estimates were usually higher than those for Ireland, Wales or England (p. 451). However Venn provided (p. 467) a series of line graphs representing actual and forecast yields (made in September of each year) in England and Wales 1906-1932. There is a remarkable accordance between the actual and forecast for each grain over the period, with the forecast consistently too low. Venn concluded (p. 469) by saying "that actual yields may not be quite as low as the official figures suggest" and "extreme conservatism" in estimating crop yields "should by every possible means, be avoided."

separate maps. The production number patterns would have been improved if county yield estimates were available for the more highland-upland and lowland parts of the counties separately. Consideration of methods of increasing the sophistication of the number patterns was abandoned since further manipulation of the statistics introduces results which are not always strictly comparable. Here all of the rounded original statistics are retrievable.

The pattern
$$\begin{array}{r} 0 \text{ t } 100 \\ 9 \text{ } 629 \end{array}$$
 reveals a situation which could occur in the Dumfries, Kirkcudbright or Wigtown upland or in parts of Argyll and other western mainland and island areas where grain is not a large percentage of crops and grass acreage. There is no wheat grown. Barley acreage is shown as a trace, which is ordinarily less than 10 acres in the highland-upland regions. In this case the trace is so small that the rounded figure of 100 has been awarded to oats. In comparison the pattern
$$\begin{array}{r} 0 \text{ t } 99 \\ 9 \text{ } 629 \end{array}$$

shows that there is no wheat and the trace of barley is of some importance though still small in relation to oats. The original rounded acreage can be found by starting with the total crops and grass acreage 62,900, finding the amount occupied by 9 per cent of it in grain and noting that barley could then occupy something in the order of 50 acres. It does not in fact do so, because a trace has been defined as less than 0.5 per cent and except in Aberdeen, usually less than 10 acres. In Aberdeen with a much larger grain area than the other units, a larger more significant trace occurs.

The pattern t 14 86 refers to an area with a
 34 6153

a very large acreage of crops and grass and a study of the patterns reveals at once that lowland arable Aberdeen is the only unit capable of providing 615,300 acres. Here the trace is still anything less than 0.5 per cent and it could refer to as much as 1000 acres of wheat except that the total of barley and oats equals one hundred per cent.

A glance at a sequence of annual patterns for arable Aberdeen would reveal that in fact the wheat acreage is very small. The output section of the number pattern on the separate map for the same year reveals precisely how small

19 16 13 The output is given as
 .3 139 1213

.3 hundred tons or 30 tons and to arrive at that total at the estimated yield about 32 acres of wheat must have been involved.

In the same pattern t 14 86 the position of barley
 34 6153

might seem relatively insignificant compared to oats, but when the acreage is obtained from the crops and grass base figure and thence from the grain acreage, it is found that over 12,900 acres are in barley. This compares very well with the acreages possible in others of the 54 divided county and county units where barley occupies a much higher percentage of a smaller crops and grass and grain base. If the pattern had been t 14 85 the wheat acreage might have been quite significant, especially when compared to units in western and southwestern Scotland.

Since barley has become the major crop over so great a part of the arable lowland the patterns have changed. A typical acreage pattern in arable Aberdeen is

| | | | |
|---------|---------|----------|--------------------|
| 4 40 56 | in Fife | 18 56 26 | and in any lowland |
| 32 6073 | | 32 2212 | |

part of the country in the southwest or west

| | |
|---------|---|
| 1 30 69 | . |
| 13 1375 | |

The comparable output patterns in arable Aberdeen are

| | | | |
|--------------|--------|-------------|-------------------|
| 25 27 22 | , Fife | 28 28 22 | and in the south- |
| 99 1036 1206 | | 180 547 196 | |

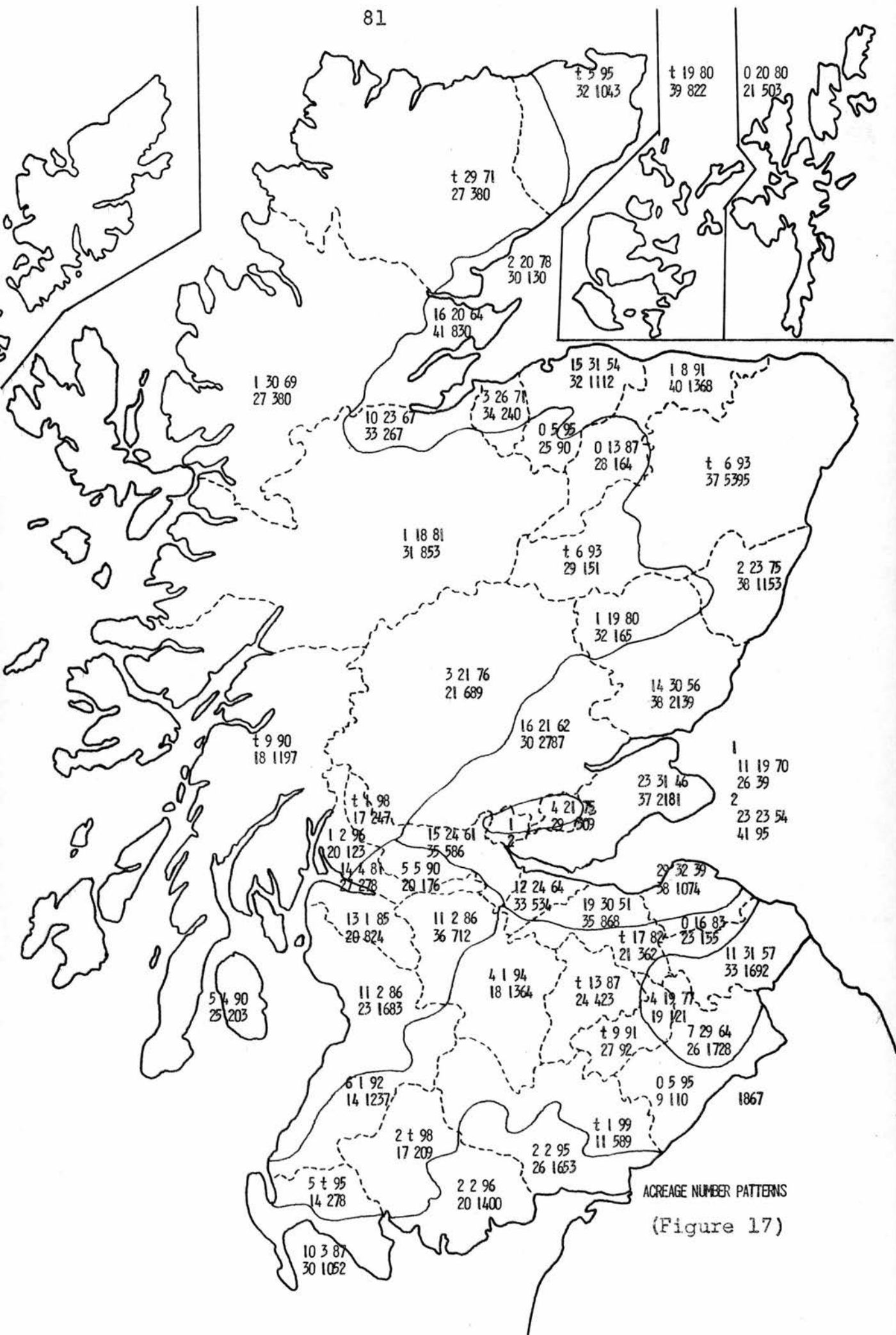
west and west the pattern is usually

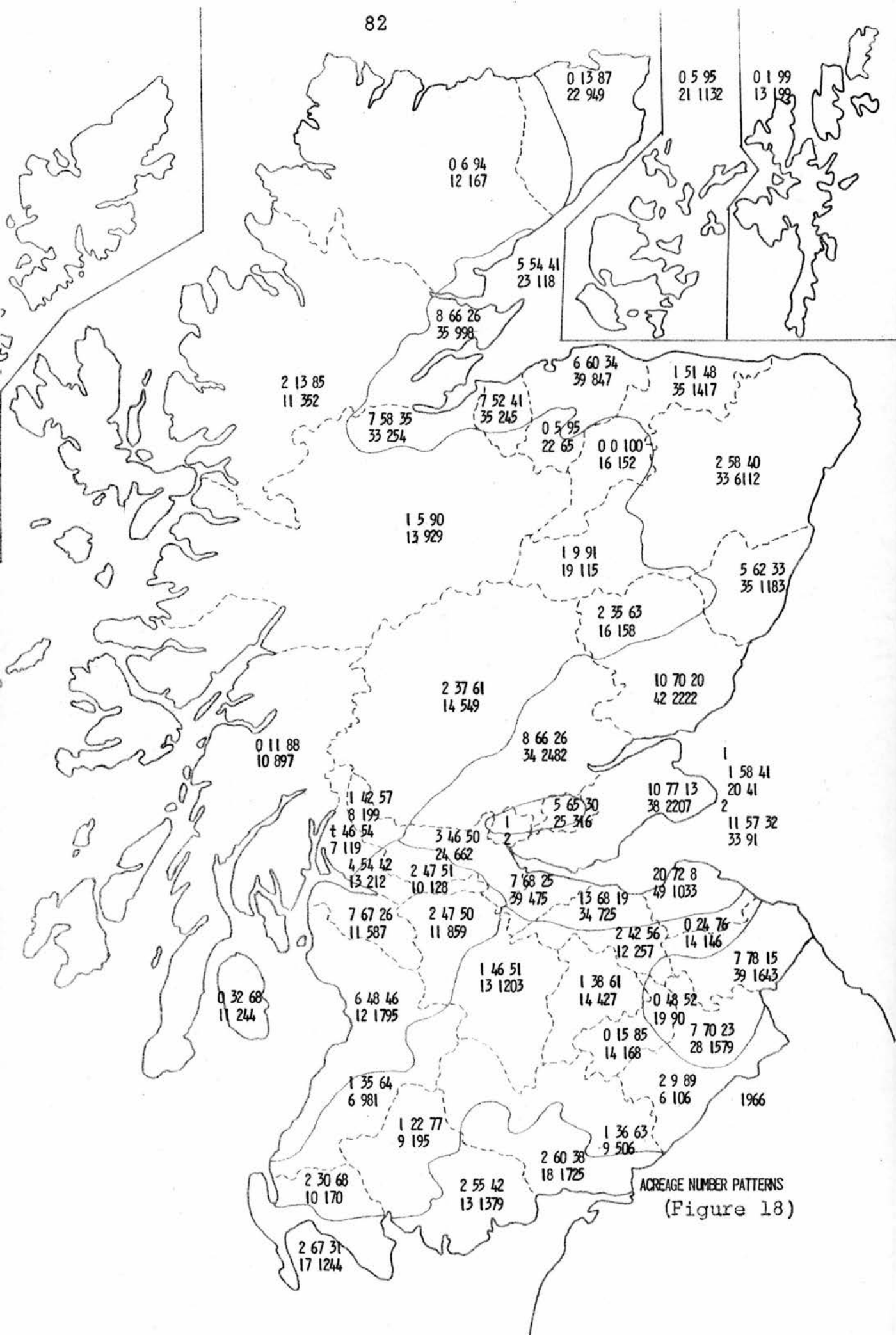
| |
|----------|
| 24 23 19 |
| 2 61 118 |

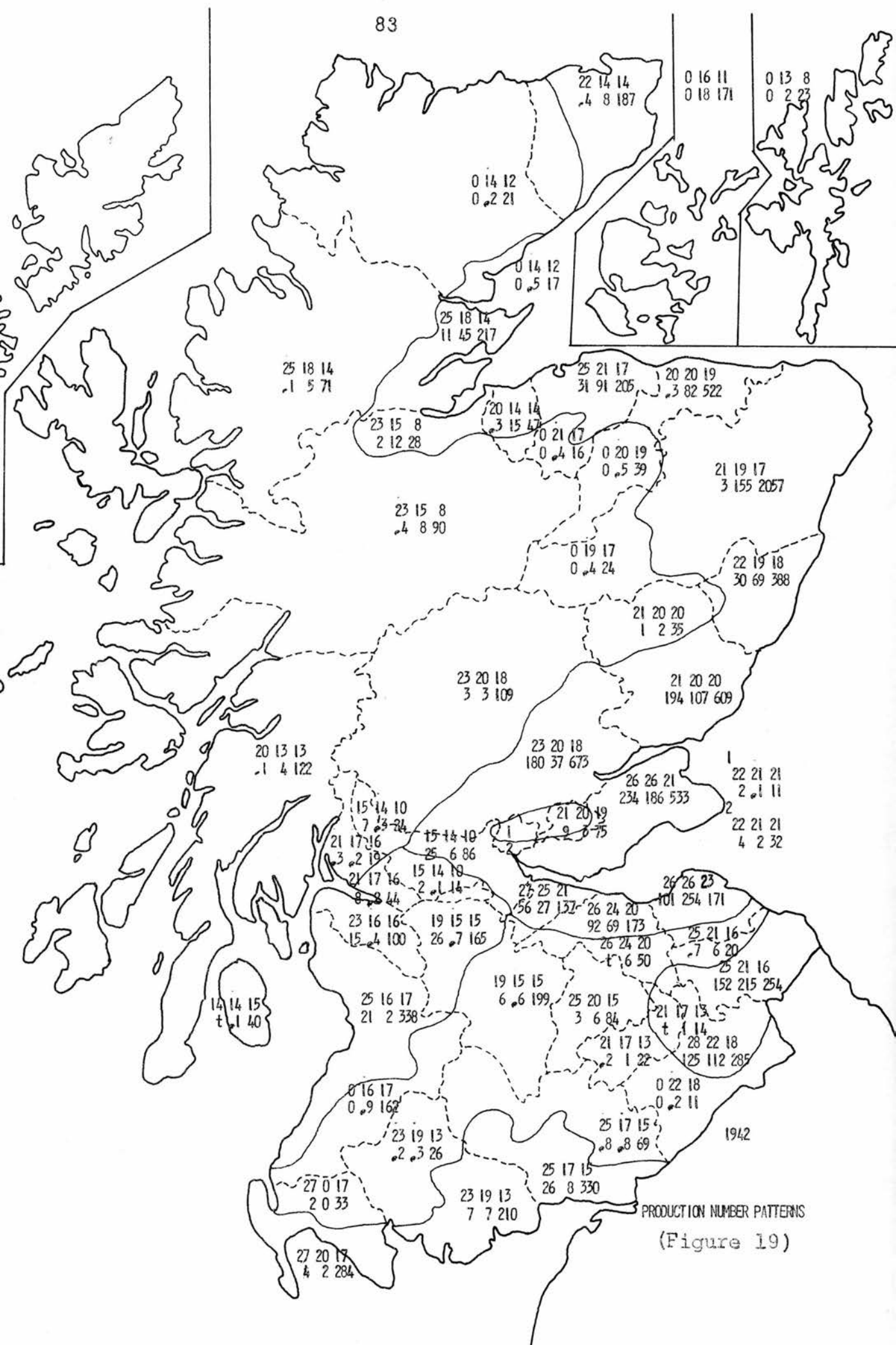
and reveals much lower tonnages in an area where grain is not so important as a cash crop. None of these sample patterns look interesting without the map and the opportunity to compare them with adjacent grain areas in the same year or down a sequence of years.

The number pattern maps are shown here in a few examples in Figures 17, 18 and 19 and since they are intended mainly for reference use the remainder are to be found in complete form in Appendix D and E. They were created in the search for a method of regional and sub-regional comparison and the retention of as much numerical detail as possible is deliberate in order to ensure retrievability and good unit comparison. The material provides possibilities for use for research taking place in cognate and specific fields.¹ The patterns bear a

¹ Such maps would be valuable to meet the purpose outlined by Wiedel, J.W., Factual Maps for the Visually Handicapped, The Professional Geographer, 8(3) May 1966 pp 132-139.







PRODUCTION NUMBER PATTERNS
(Figure 19)

slight resemblance to work carried out in Sweden by Petrini on number patterns¹ but they originated from ideas advanced by Tobler.²

Conclusion

The number pattern maps offer single year patterns for the whole of Scotland at once. Both acreage and production patterns are possible. The changing patterns are particularly noticeable in the pre-war, war and post-war years or following government intervention or its removal, or recently in the massive changeover to barley. Areal comparability can be checked by reference to the total crops and grass acreage. A variety of activity is relatable at once. Retrievable rounded data is available. A disadvantage is that the maps are still in workshop form and not neatly compartmentalized into fixed patterns. They are valuable as a study tool and reference check. At one point the data were returned to a tabular form but the loss of visual impact was so striking that the material was returned to the maps designed for it. Experimentation revealed the need for a measure of varying ability to produce grain in different parts of the country and the number pattern maps offer a means of showing the variation.

1. See Petrini, F., in a brief section where eight figure number groups are used to give a multi-dimensional picture of rural life in Sweden, in Hedbom, O., From Manual to Automated Plotting on Thematic Maps, International Yearbook of Cartography 2(1962) pp. 147-150.

2. Tobler 1963 op cit p. 75.

Graph Sections and Graph Section Maps

Sections are an old device on geological maps representing sub-surface patterns but have had less application to surface patterns. When presented in proportional area form, general information can be retrieved from them. Proportional cubes, circles and spheres were rejected because of the difficulty of assessing their content (unless it is labelled on them) and in comparing them. The three dimensional forms are valuable where the range of values may be conveniently grouped into half a dozen or less standardized sizes. Proportional cubes would have cut down the size of the proportional area bars and might have made possible the showing of all four sections on one map if they were placed en echelon. However the visual handicap makes them less valuable from the retrievability point of view and the en echelon placing adds further difficulties.

Four sections based on grouped parishes were desirable from the beginning. A first essential was a line cutting through the greater Glasgow and Edinburgh areas as well as through some of the most productive land in Scotland. The east-west section has proved very valuable in showing the shrinking area of farmland in the parishes around the cities. A section across the southern part of the country from Wigtown to Berwick was needed to include an area of the southwest geared to livestock raising and dairying and extending through sparsely populated hill farms to

the fertile lowlands and grain farms of Roxburgh and Berwick.

Two south to north sections were required to illustrate the differing patterns and increasing difficulties by degree of latitude and cutting through very varied terrain.¹ One taken through Kirkcudbright, central Lanark and on to eventually cut through the most productive part of northeastern Aberdeen passes through the greater Dundee city area. Another extends from a base in Wigtown through Ayr and on through highland Perth and Inverness to Moray Firth and turned approximately 30 degrees to continue through Caithness, Orkney and Shetland.

The proportional area graphs were drawn first to provide a measurable comparative picture in the years 1866, 1942 and 1966. The year 1942 was chosen to represent a peak war year of production. Some adaptation of shape of the individual proportional area bars was necessary to get them on the maps with their base located directly on the parish or grouped parishes to which they refer.¹ After some experimentation the shapes were standaradized at 2.5 mm., 5mm., and 1 cm. to improve and simplify their measurability. The individual bars are placed squarely over the base unit but because of the large areas in grain production in the eastern arable lowlands, the four sections have had to be shown on three separate maps. Consequently the graph maps

1. See Appendix B for the identity of the parishes, singly or grouped used in the section graphs and graph maps.

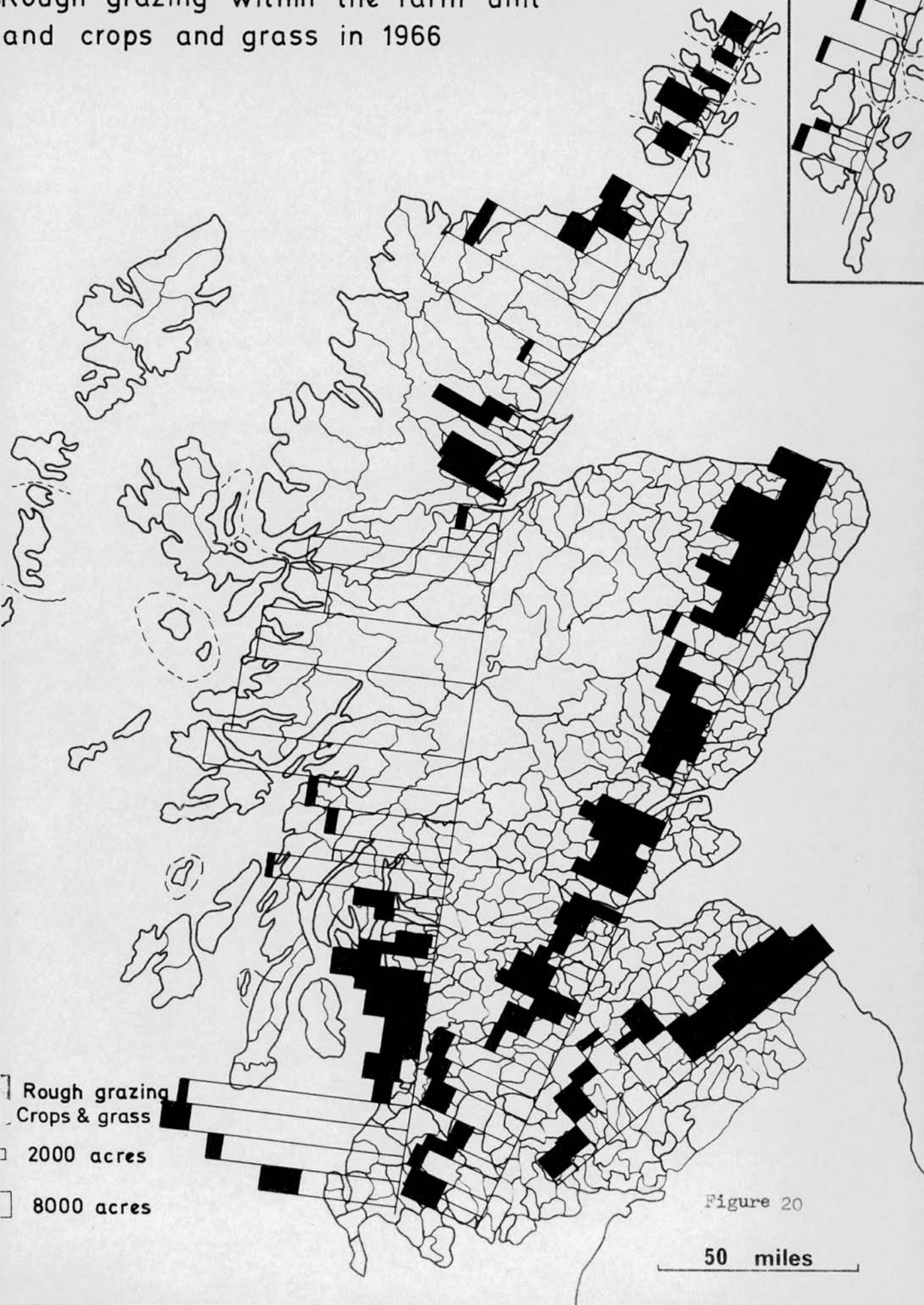
fall short of the desired total sample section picture. Nevertheless they offer an exceptionally striking, sharply clear picture of regional patterns.

Graph section maps are offered showing the 1966 grain acreage and its component parts, and rough grazing within the farm unit (Figure 20). The former was selected to emphasize the position of the lowlands and the latter to show the highland position. Another pair show the extent of overall change to barley between 1956 and 1966. They represent a more dynamic picture and show that the sections may be used for many types of both static and dynamic situations.

Graph sections without maps show the same classes as the maps but in a comparative fashion with three separate years and one section per page. What is gained in depth is lost in regional comparison. Another group is used to pick out the low and high points in tillage and grain acreage in 1939, 1942 and 1946. Other experiments could have been presented but these are suitable examples to show the versatility of the method, in a country with sharp changes in altitude, aspect, soil and parent rock patterns, moisture regime and temperature values in such a short compass.¹ The low and high points in tillage

¹ A valuable short commentary on the differing patterns which may be found on traverse is that of Ogilvie, A.G., *The Debatable Land in Scotland*, *The Scottish Geographical Magazine*, 60(1) June 1964, pp. 42-45. Reference was made to the substantial parts of the country between 400 and 1,100 feet and Ogilvie stated on page 42 "These limits of altitude have an important bearing upon farming: most of the good arable country lies below 400 feet but ploughed land is found as high as 1,100 feet, the upper limits being higher in the drier east than in the wetter west."

Rough grazing within the farm unit and crops and grass in 1966



and grain acreage illustrate some of the difficulties outlined by Ogilvie and may be seen in Figures 21 and 22. Other examples are to be found in the discussion on the patterns of distribution.

Conclusion

The four sections represent a very good cross-section of Scotland's varying ability to grow grain crops. It is disappointing that all four at the scale chosen could not be presented on one map at the page size. The scale could not be reduced further because areas of low grain acreage in the huge parishes such as Killin and Fortingall in Perth and Laggan, and Boleskin and ~~Abertaff~~ in Inverness, were already out of reach of the scale chosen (ie. they each had much less than 50 acres of grain in the years measured).

The graph section maps have the overwhelming advantage of providing a very comprehensive sample of Scotland in startling contrast and this overrides any difficulties of scale. Data retrievability and areal comparability are good and a multi-dimensional picture can be presented. They have a wide application in presenting any populations of surface phenomena in Scotland.

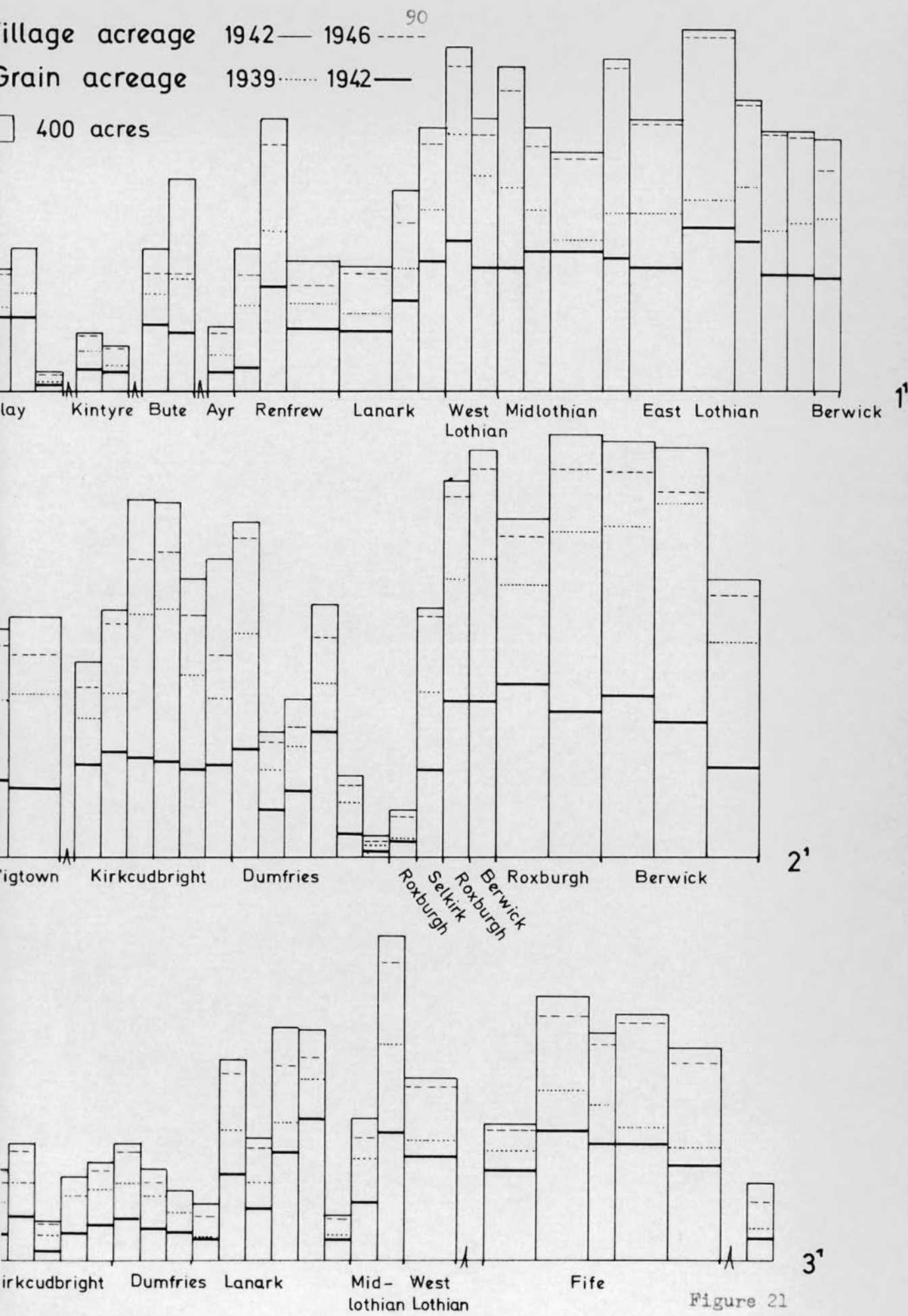


Figure 21

Tillage acreage 1942 — 1946 - - - - 91
 Grain acreage 1939 1942 —

□ 400 acres

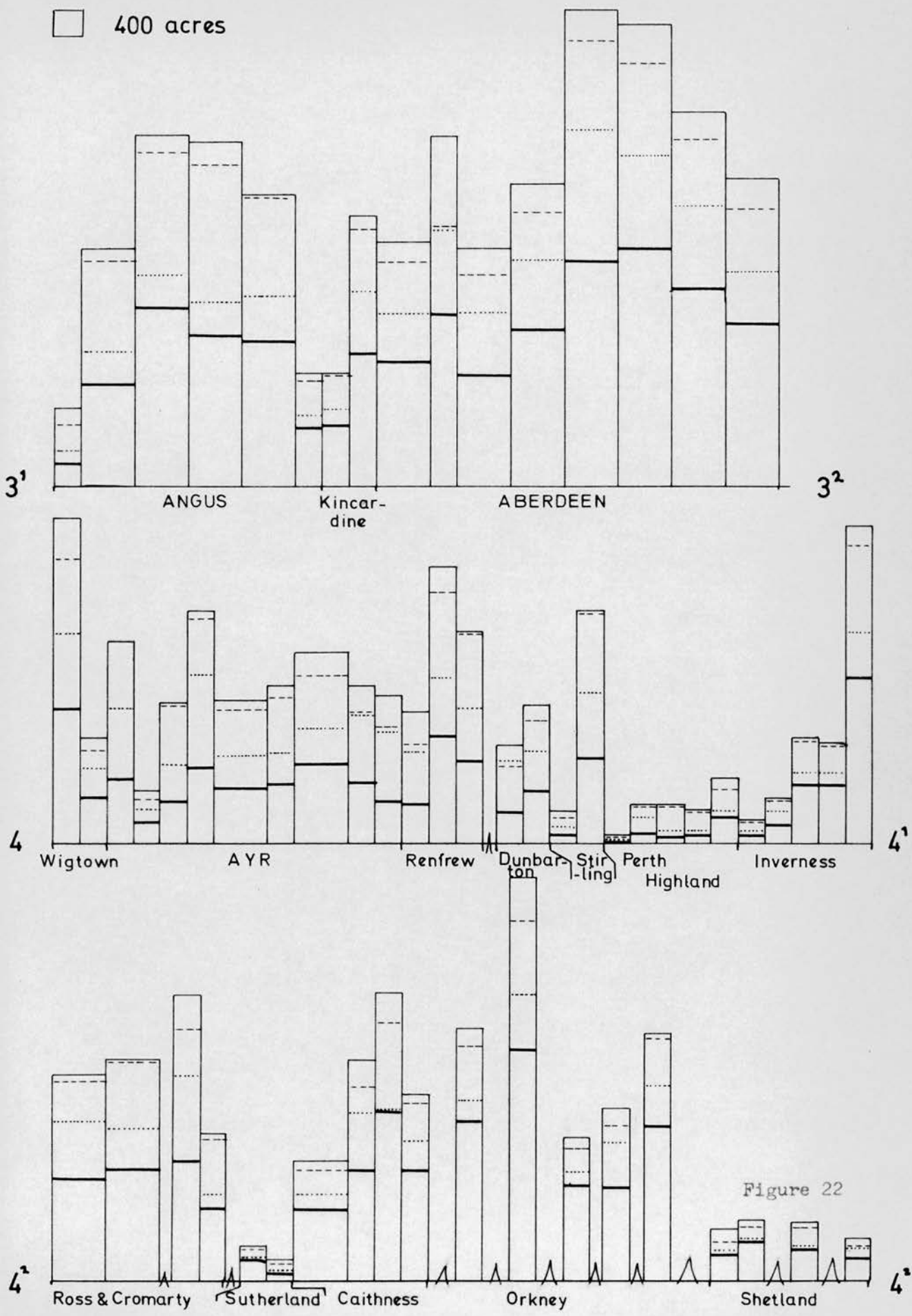


Figure 22

Raised Statistical Surfaces

Introduction

None of the methods used so far have produced an ideal form of areal comparability. In fact the problem is only slightly less troublesome than when dealing with the uniform surfaces and distributions such as are found in parts of the Canadian Prairies or American Midwest.¹ Although the strong physical characteristics of Scotland are imprinted on any distributional map and interpolation is not difficult, the individual unique shapes of its parish administrative divisions flout any conventional methods of combining them to achieve equal area comparability. The search for a suitable method to deal with the areal problems has led to an examination of the possibilities to be found in trend surfaces.

Improved isarithmic mapping, simplified description and comparison of patterns, construction of process-response models, and comparative areal analysis have been suggested as laudable aims to be achieved by the application of trend surface analysis to conventional geographical problems.² "Trend surfaces can thus be considered as response surfaces from which aspects of origin, dynamics or process may be inferred, wherein variations in form may be thought of as responses to corresponding

1. See page 43 in Robinson, A.H., *The Necessity of Weighting Values in Correlation Analysis of Areal Data*, AAAG, 46(2) 1956 pp. 223-236.

2. See Page 6 in Chorley, R.J., and Haggett, P., *Trend Surface Mapping in Geographical Research*, Institute of British Geographers, Trans. 37(1965) December pp. 47-67

areal variations in the strength and balance of the controlling factors" ¹ This statement is basic to the approach adopted. Ajo has used statistical surface models in analysis providing density patterns expressed in isolines and later by frequency of occurrence of major groups of density data. ²

Raised Divided County Block Surface Maps

A part of the solution was found in raised statistical surfaces. The raising of block surfaces has been depicted in numerous books and papers. ³ The raised surfaces are presented for the more arable lowland areas of counties only and are similar to those used by Jenks ⁴ except that the shapes are much less uniform than the state divisions in the United States. The vertical element in the surfaces has been sub-divided into the individual grain components and they offer a very striking picture of Scotland's varying abilities to produce grain crops. Acreage patterns for thousands of

1. Chorley and Haggett 1965 p.47, op cit p.92.

2. Ajo, R., Three Dimensional Patterns and Models Based on Polish Statistics, a Methodological Study in Planning Geography, Geografiska Annaler 47B(2)1965 pp.101-110.

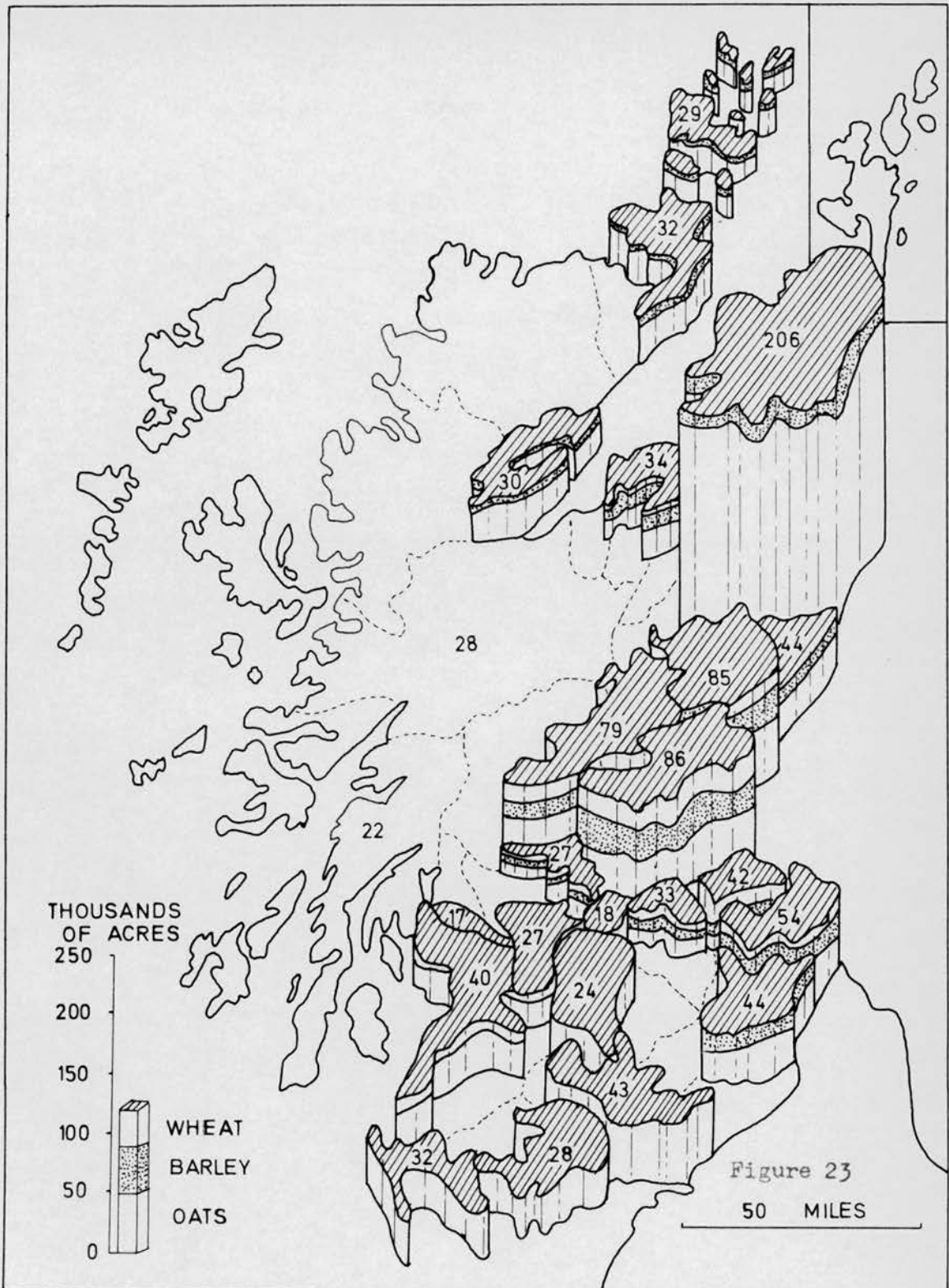
3. Examples are to be found on pages 209 and 210 in Yule, G.U., and Kendall, M.G., An Introduction to the Theory of Statistics, C. Griffin, London, 14th Edit. 1965. An original drawing by Pollack, L.W., in Conrad, V., and Pollack, L.W., Methods in Climatology, Harvard, 1950, is reproduced by Morgan, M.A., on page 729 in Chorley, R.J., and Haggett, P., Models in Geography, Methuen, London, 1967. Other useful models are to be found in Jenks, G.F., Generalization in Statistical Mapping, AAAG 53(1)1963 pp.15-26 especially on pages 18, 19 and 20.

4. Jenks, G.F., The Data Model Concept in Statistical Mapping, International Yearbook of Cartography 7(1967) pp.186-190. The models in 8 figures following page 186 are outstandingly clear.

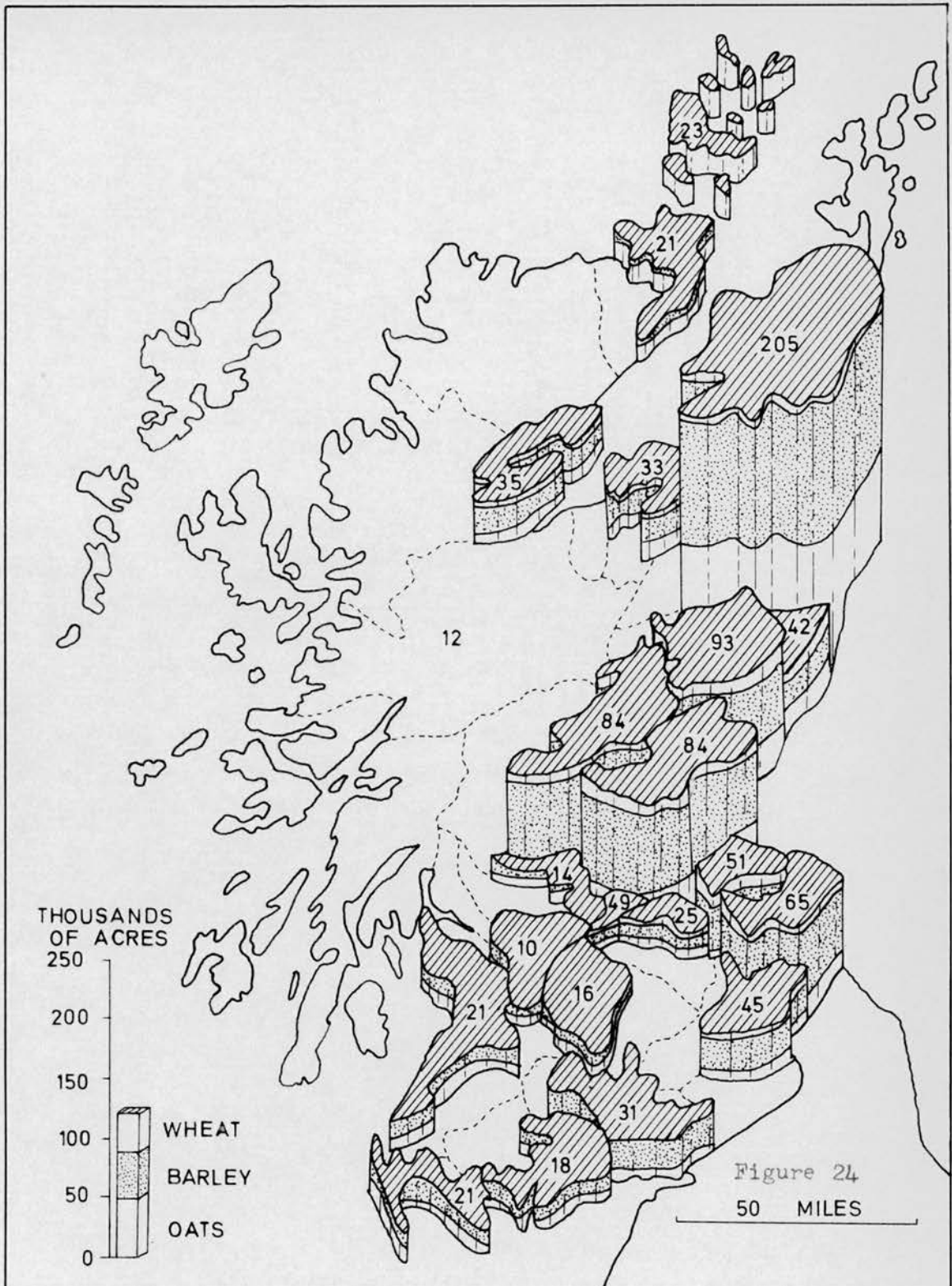
acres of grain in 1866 and 1966 in Figures 23 and 24. Total grain production in hundreds of tons is shown in a sample of years in 1889 when yield estimates were quite reliable , in the peak year 1918, the trough year of 1939 when grain acreages reached a point even lower than in 1914 in many counties and in the last year of the publication of yield estimates by counties in 1964.¹ The cut-off point on the vertical scale was chosen to eliminate the highland-upland parts of counties and to heighten the comparison with the arable lowlands. The undifferentiated highland-uplands and islands have not been raised except in the case of upland Lanark. After several experimental maps when highland Inverness, Argyll and highland Perth were raised to show ten thousand tons or more of production, the effect was to credit the production to a very large rough territory when it should have been localized within the area. When this was done the production fell below the reach of the vertical scale chosen. Upland Lanark produces about the same output of grain as more arable lowland Lanark but the components are different and the upland area has no alternatives such as are available to the more arable half of the county (Figures 25, 26, 27 and 28).

At a different scale, solutions to the problems would have been found at the grouped parish or parish level. If this had been done most of the grain growing ability of Argyll would be found in the islands of Islay, Mull and

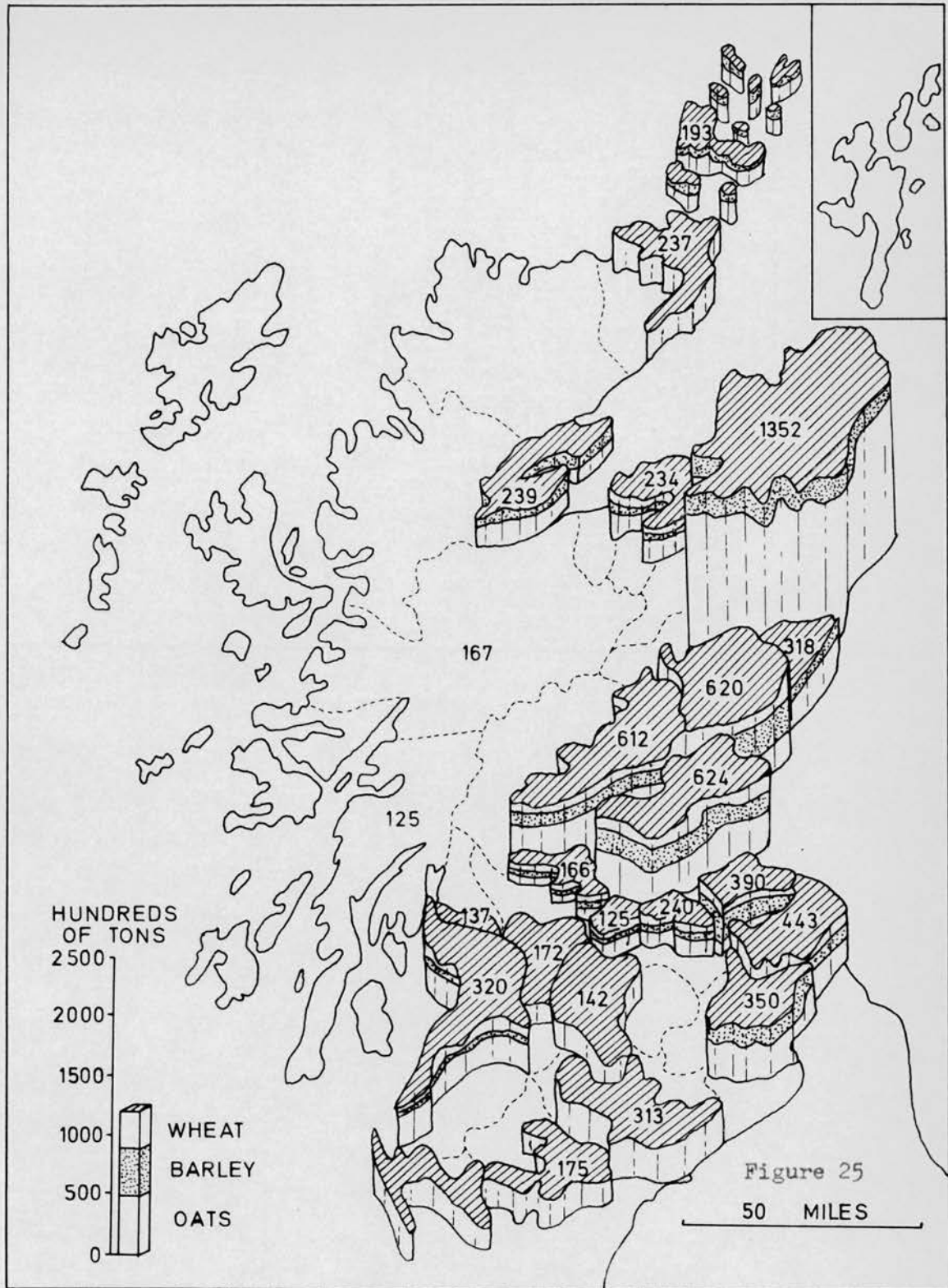
1. The published yield estimates of 1965 were by regions and were not so detailed as in 1964 or in previous years. For the five years before 1889 yield estimation was in an experimental stage and estimates were closely checked with other years and a divergence from the normal published.

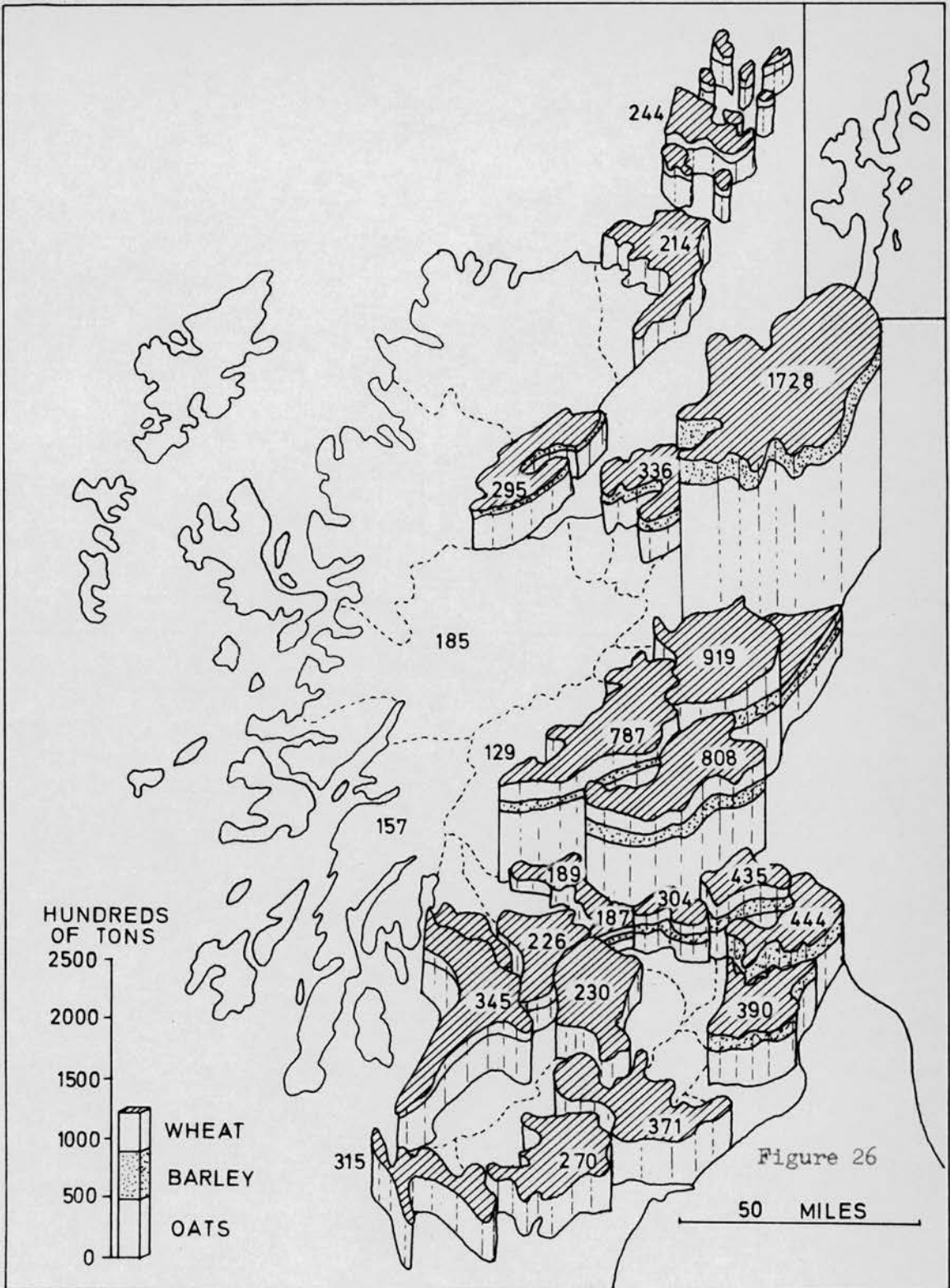


Grain acreage, by divided counties, in 1866.

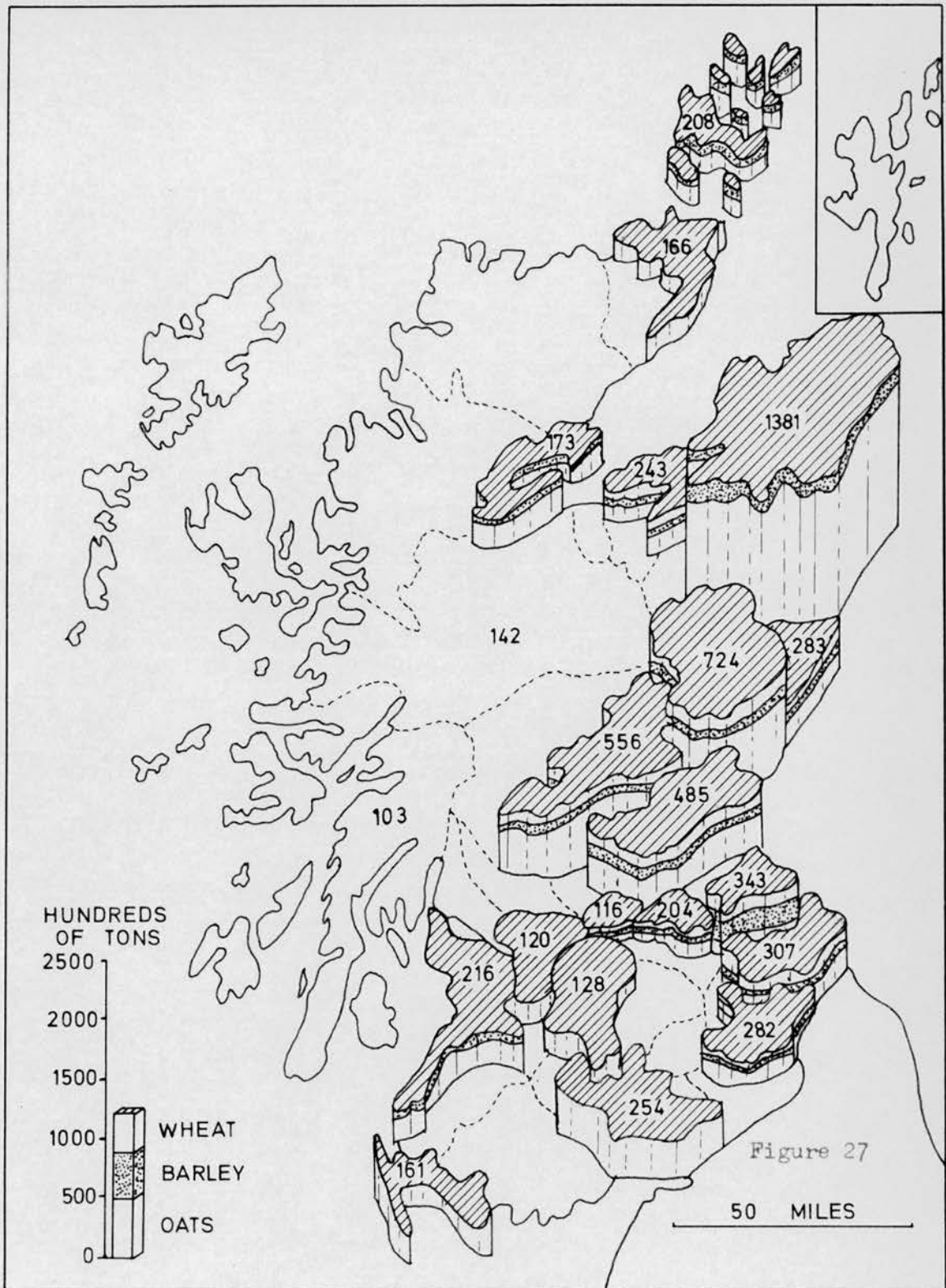


Grain, by divided counties, in 1966

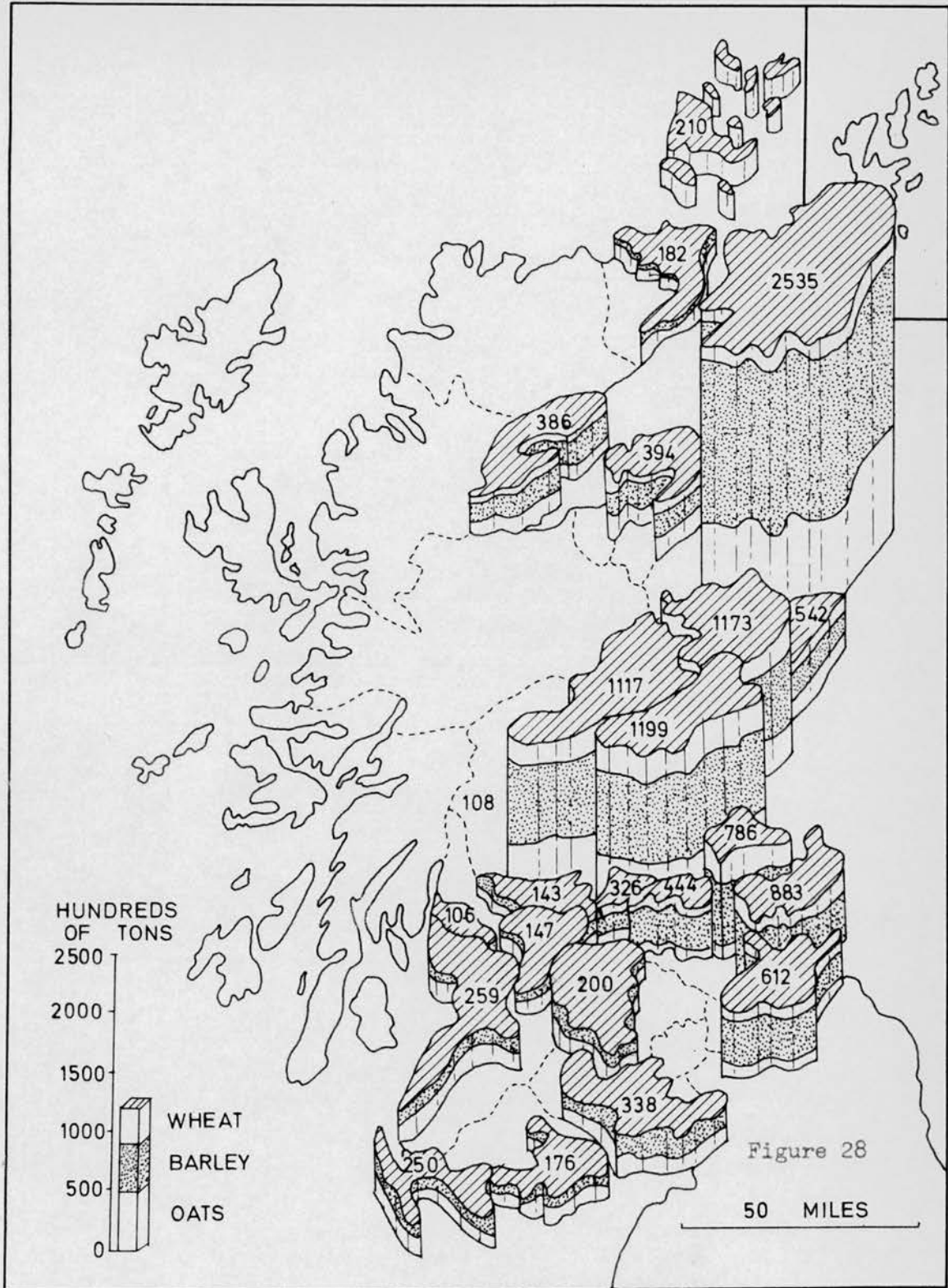




Estimated total grain output, by divided counties,
in 1918



Estimated total grain output, by divided counties, in 1939



Estimated total grain output, by divided counties,
in 1964

Tiree and most of that for undifferentiated highland Inverness and Ross and Cromarty, in North and South Uist and in Lewis. The stepped frequency surface models of arable Aberdeen and the south Forth area use the parish basis and may be seen in Figures 32 through 45. A model for the whole of Scotland on the parish basis is shown in Figures 46 and 47. At the countrywide level the raised statistical surfaces by divided counties has good visual impact and they serve to highlight the differing regional patterns.

Scaled Vertical Lined Working Maps

Another attempt at depicting realities on the ground on a map has been made by erecting scaled vertical lines in the centre of each parish on the map of Scotland. At first this was done on the grouped parish map but the results were overemphasized by grouping the acreages of total grain in the 636 more arable parishes into 220, in comparison with the low pattern from the 225 large highland-upland parishes. Later a parish map of scaled verticals representing total grain acreage in 1966 was prepared as a basis for the next step (Figure 29).

"Smoothed statistical surfaces are inferred by interpolation between elevated control points."¹ "It makes no fundamental difference whether this conception (surface relief pattern) derives from looking at a series

¹ Jenks, G. F., page 19 in Generalization in Statistical Mapping, AAAG 53(1)1963, pp. 15-26.

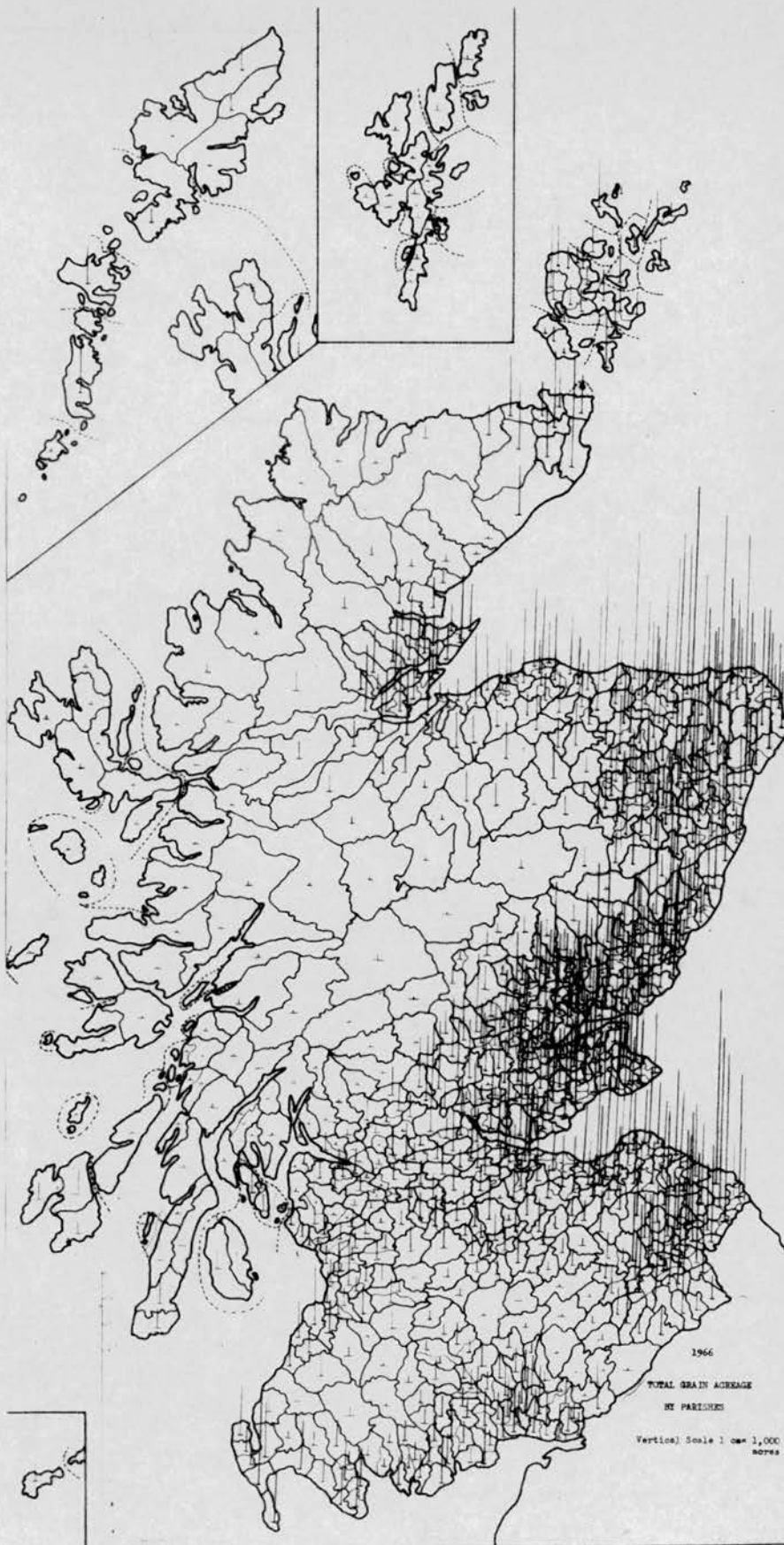


Figure 29

of averages of arbitrary unit-areas, such as counties or states (choroplethic), an arrangement of non-arbitrary areas of relative uniformity (dasymetric), an array of individual numbers (point data or spot heights) or the surface configuration of a continuous variate (isarithmetic, hachured, shaded). In each case the map attempts to portray the variations of a statistical surface with greater or lesser efficiency.¹ Accordingly the next operation should be to draw a trend surface on the control points erected on the scaled verticals working map. However it is at this point where the major difference between the idealistic models offered in the literature² and the application to a complicated map area presented a most difficult problem, severely taxing artistic representation. Selected block sections of Scotland can be drawn fairly easily and the desired normal trend surface demonstrated, but the desirable end was a view of the whole of Scotland in some sort of smoothed surface model form.

Block Sample Models

In actual practice the scaled verticals representing total grain acreage by individual parishes (Figure 29) were examined in perspective and wooden cubes one centimetre square, modelled to scale for the key heights. A sample of 133 parishes were represented and their grain acreage vertical cubes formed an umbrella or ridge effect

1. See on page 54, Robinson, A. H., *The Cartographic Representation of the Statistical Surface*, *International Yearbook of Cartography* 1 (1961) pp. 53-63.

2. See pages 208 and 210 in Yule, G. U., and Kendall, M. G., *op cit* p. 93.

over lesser heights, when affixed to the parish concerned. Instead of drawing a smoothed surface on this complex model of Scotland, an actual net of 15 millimetre mesh was draped so that it was held up on the tips of the cubes in areas of high grain production and lay flat in areas which had very low acreages of grain below the reach of the vertical scale of 1 centimetre to 1000 acres. This device yielded a very striking surface with ridges, peaks, troughs and relatively flat areas. The model was then photographed from several angles to give the visual impressions shown in Figures 30 and 31. A fairly coarse mesh net is preferable because Scotland presents a most complex surface with parts hiding others if viewed only from one angle, and it is desirable to look into the mesh and see some of the pattern beyond. Such a model may be constructed for any population distribution and sharply outlines the densities which are expected and which are depicted in no other way.

Summary

Despite the visual achievements of these raised statistical and other surfaces, the major problems still remain. None of the basis material is strictly comparable because it represents something unique. The parishes are all of different sizes, grouping them gives only a token degree of comparability, and their statistical components—in this case the amounts of arable land, crops and grass, rough grazing and so on, are all different and represent different bases inside the parishes. Though the raised statistical

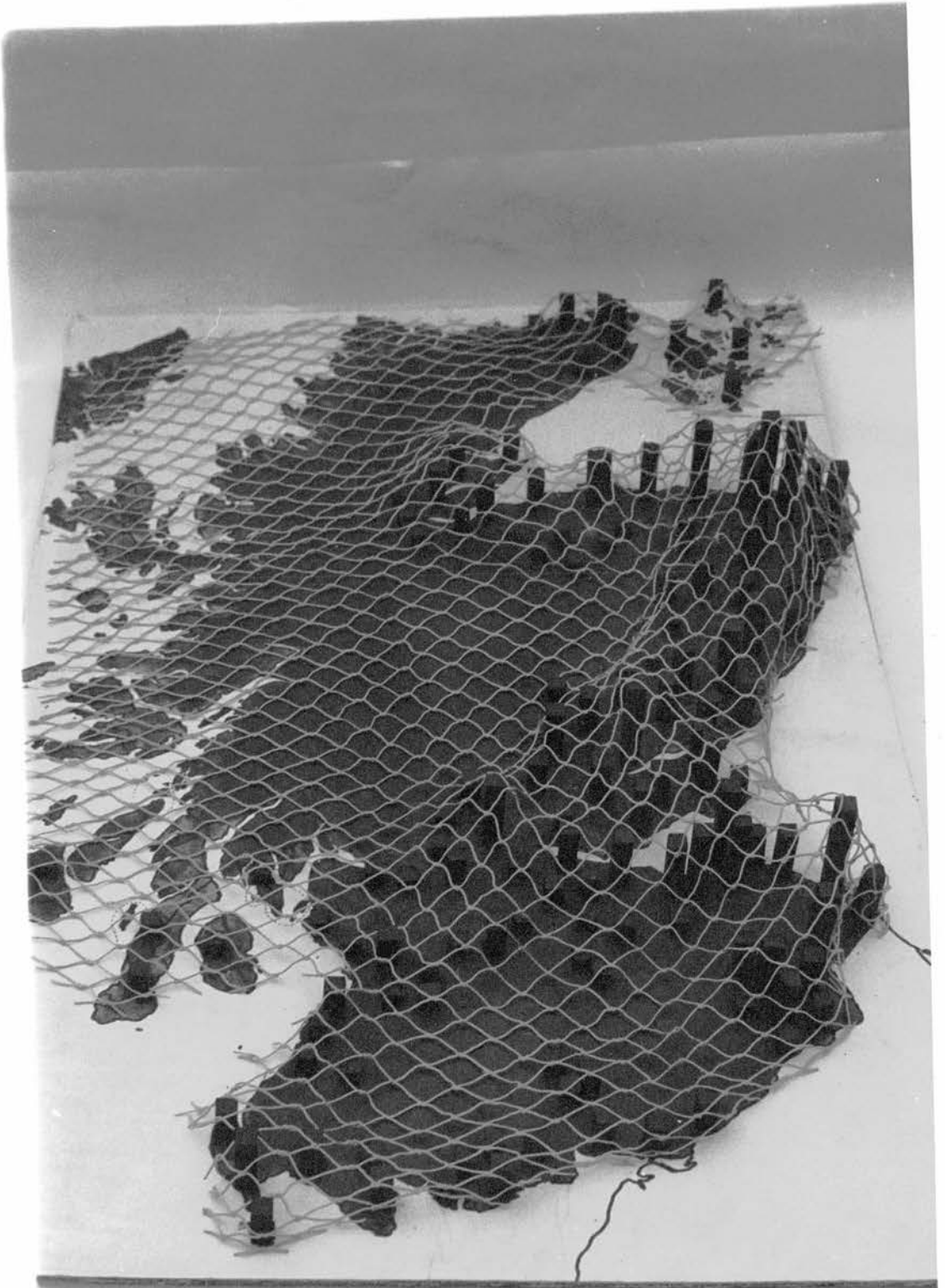


Figure 30



Figure 31

surfaces maps of Scotland (Figures 23-28 on pages 95-100) offering a sample in the hundred years, give a visual impression which faithfully reflects realities, none of the areas involved can be compared and it was necessary to give the values for each on the top of the raised surface. This gives an order of measure of size of acreage or production of grain but each refers to a base of different size. Since census data sources are not yet available on a square kilometre grid, some method of unit comparability was essential.

Unit Comparability

Using the Land Utilisation Survey maps of Scotland as a standard base ¹ two block sections were chosen. Section One encompasses all of arable Aberdeen and parts of neighbouring Banff and Kincardine (Figure 32). Section Two includes all of East Lothian, Berwick, Roxburgh and Selkirk and most of Midlothian and Peebles (Figure 33). Both offer a variety of landscape. The parish administrative boundaries were applied to each base map on millimetre graph paper. ² The area of each parish was determined in 5 millimetre squares and the values entered on a blank parish map of the section ³ (Figures 34 and 35).

1. The maps used by the Land Utilisation Survey of Great Britain used a scale of 1:625,000. Converted to the metric scale, one centimetre represents 7.667 kilometres and a five millimetre square 14.7 square kilometres.

2. Another method is that described by Wood, W.F., *The Dot Planimetre: A New Way to Measure Map Area*, *The Professional Geographer* 6(1) 1954 pp. 12-14.

3. A valuable full discussion of more sophisticated rapid techniques has been described in Coppock, J.T., and Johnson, J.H., *Measurement in Human Geography, Economic Geography* 38(2) April 1962, pp. 130-137. More particular reference to pages 135 to 137 may be made where the discussion covers the use of flying spot scanners and measurement of light methods.

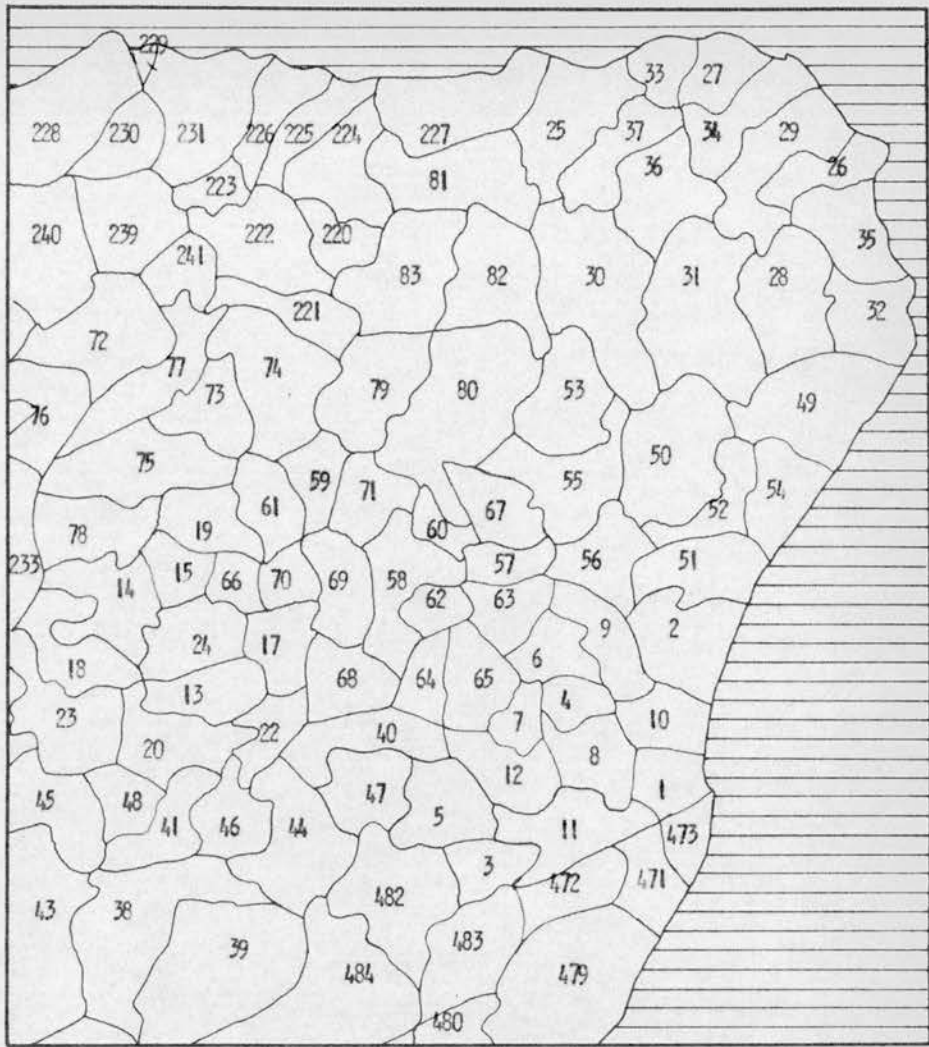


Figure 32.

Section One- Arable Aberdeen and parts of Banff and Kincardine. The parishes are identified by official parish numbers.

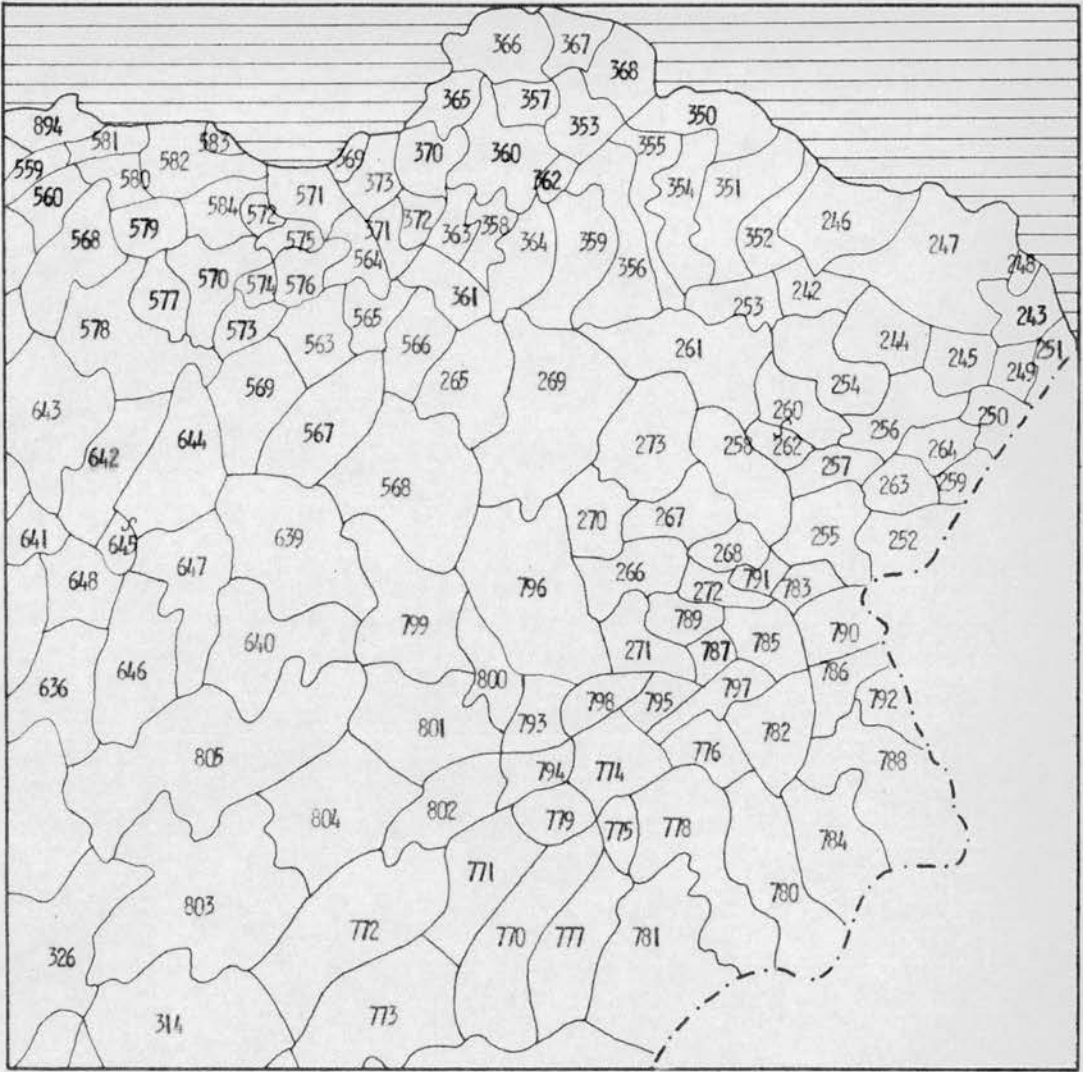


Figure 33.

Section Two- The counties of East Lothian, Berwick , Roxburgh and Selkirk, and parts of Midlothian, Peebles and Dumfries. The parishes are identified by official parish numbers.

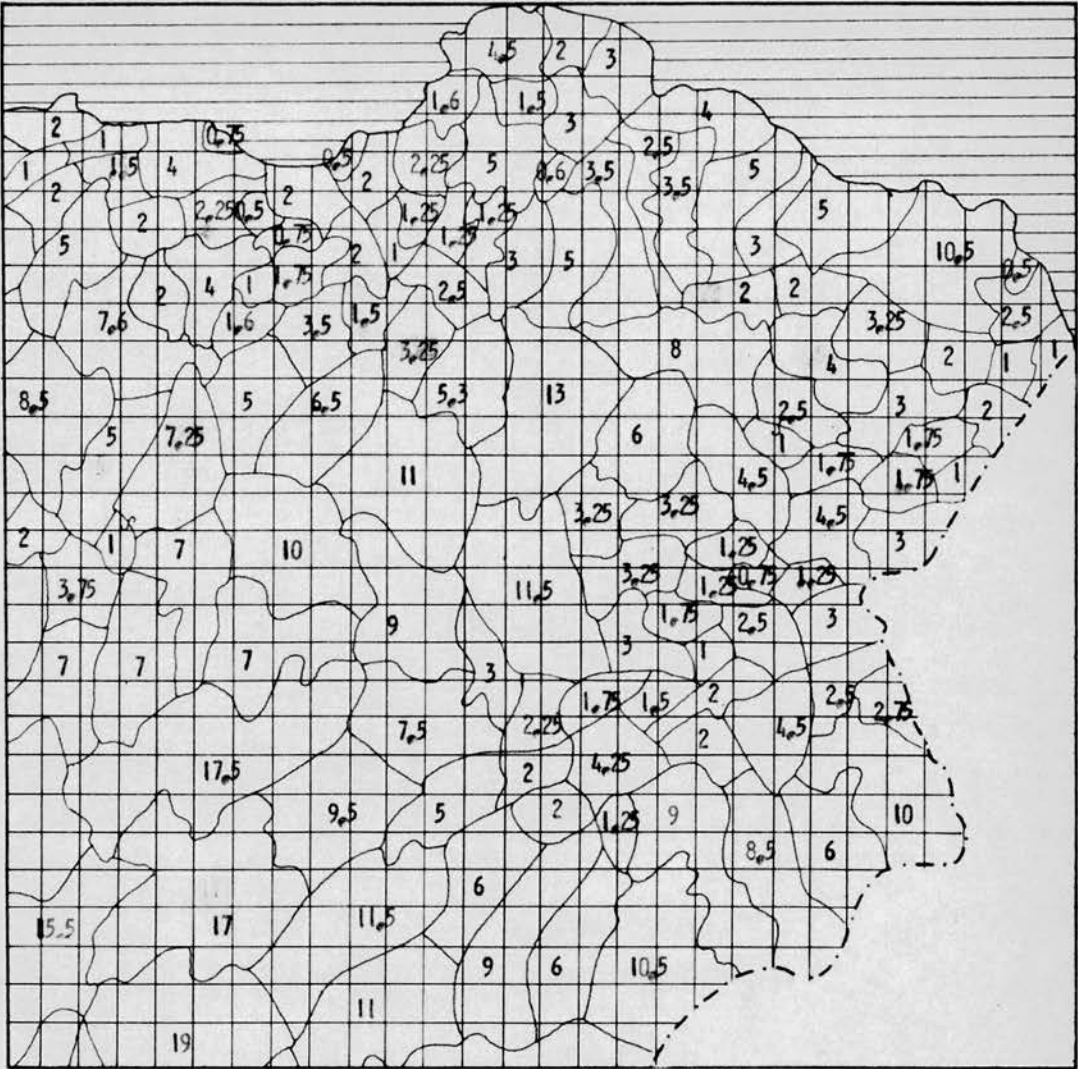


Figure 35. 1 unit = 5mm² or 14.7 sq.kms.

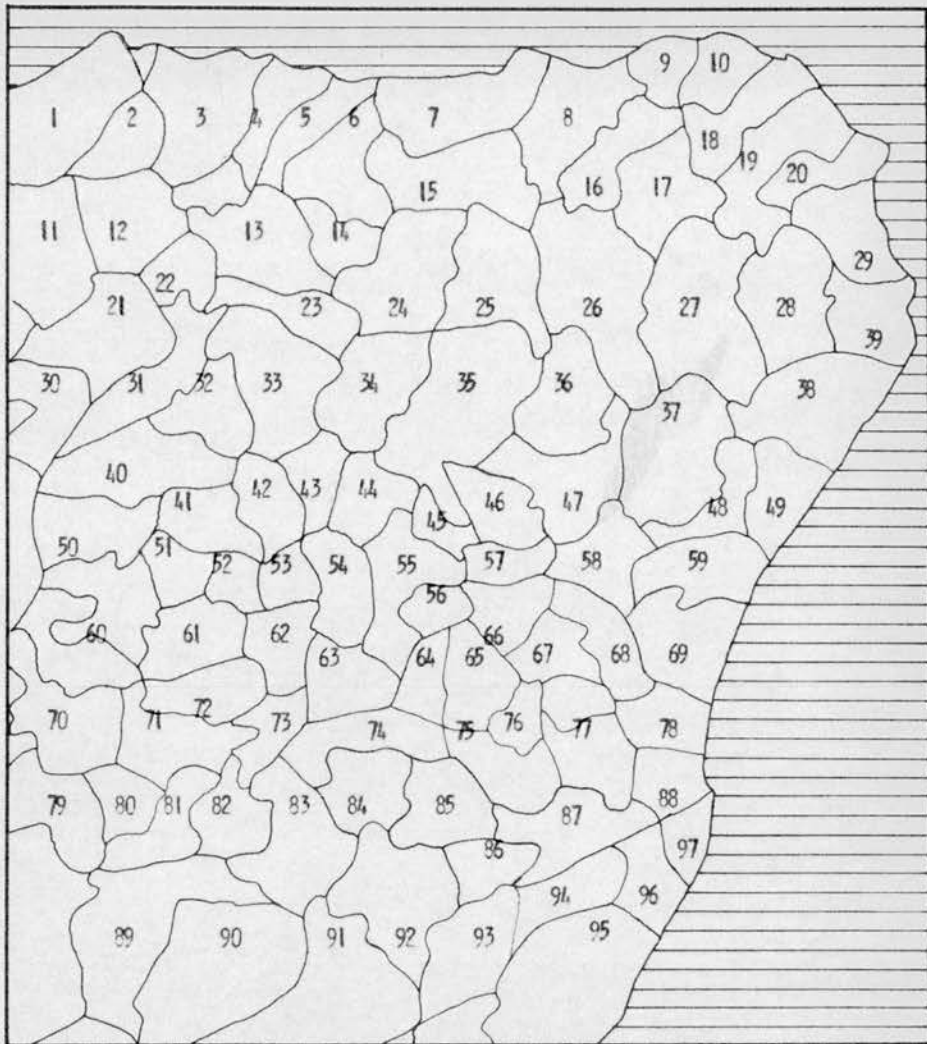
(1:625,000)

Section Two- superimposed grid of 5 millimetre squares with the number of 5 millimetre squares in each parish entered.

The unit-area number-maps have then been viewed from the southwestern corner in each of the two sections and a uniform block grid of five millimetre squares drawn tilted approximately 30 degrees away from the viewer, in the area below the key maps . On a blank parish map consecutive numbers were then assigned to the parishes in roughly parallel rows across the map, using the same total of numbers for most lines but adding extra where the coastline warranted it. The same consecutive numbers were then entered in rows on the tilted control grid below the key map (Figures 36 and 37). Occasionally very small parishes were combined in order to include them in reasonably orderly lines.

Unit value for each 5 millimetre square per parish was then determined by dividing the basic statistical data to be represented, by the number of squares in the parish for which the data applied. When parishes were less than 25 square millimetres, the values in them were multiplied to bring them up to that value or they were combined with a neighbouring parish. The statistical values representing one square were then entered on blank key maps under the titles- number of holdings, acreage of wheat, barley, oats, total grain, crops and grass and rough grazing and fulltime male labour employed. The results are unit area number maps which are areally comparable since the values refer to a characteristic unit of 14.7 square kilometres on the ground in every case.

Using the key tilted grid to guide in the drawing, the different unit values were then raised in proportion



1 unit = 5mm^2 or 14.7 sq. kms. (1:625,000)

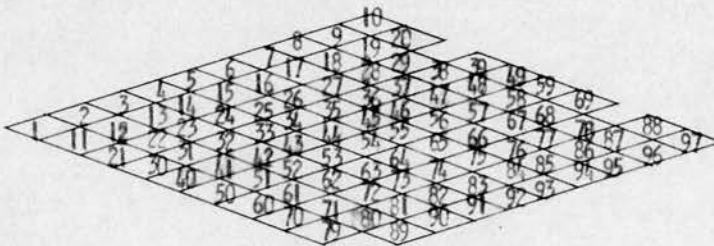
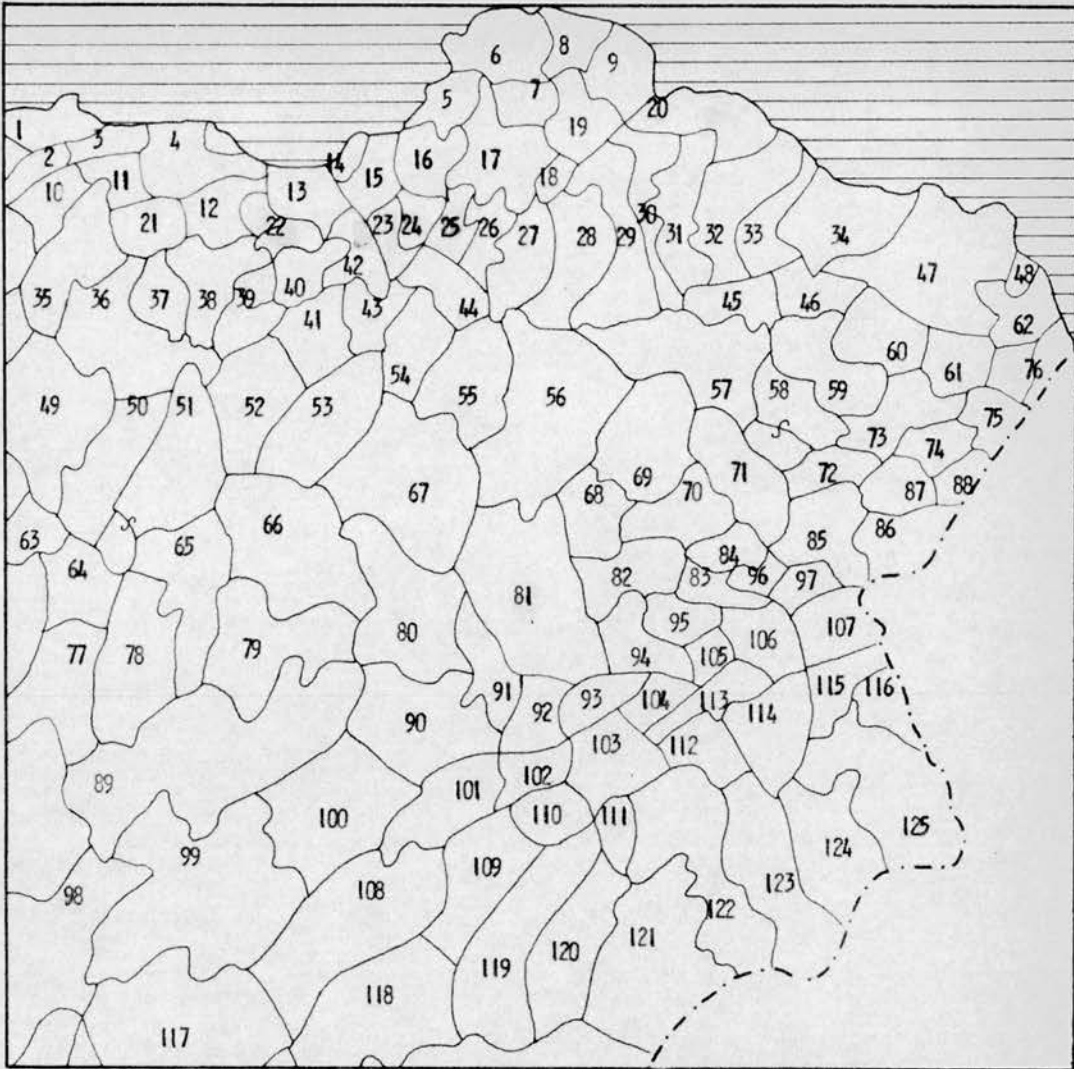


Figure 36.

Section One-the pattern of numbering adopted, showing the parishes ordered roughly in lines and their location on the grid model.



1 unit = 5mm² or 14.7 sq.kms.

(1:625,000)

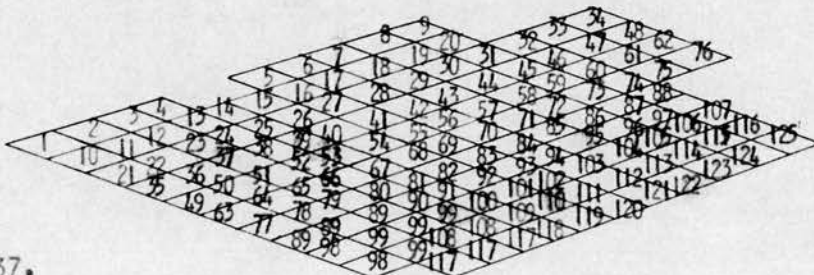


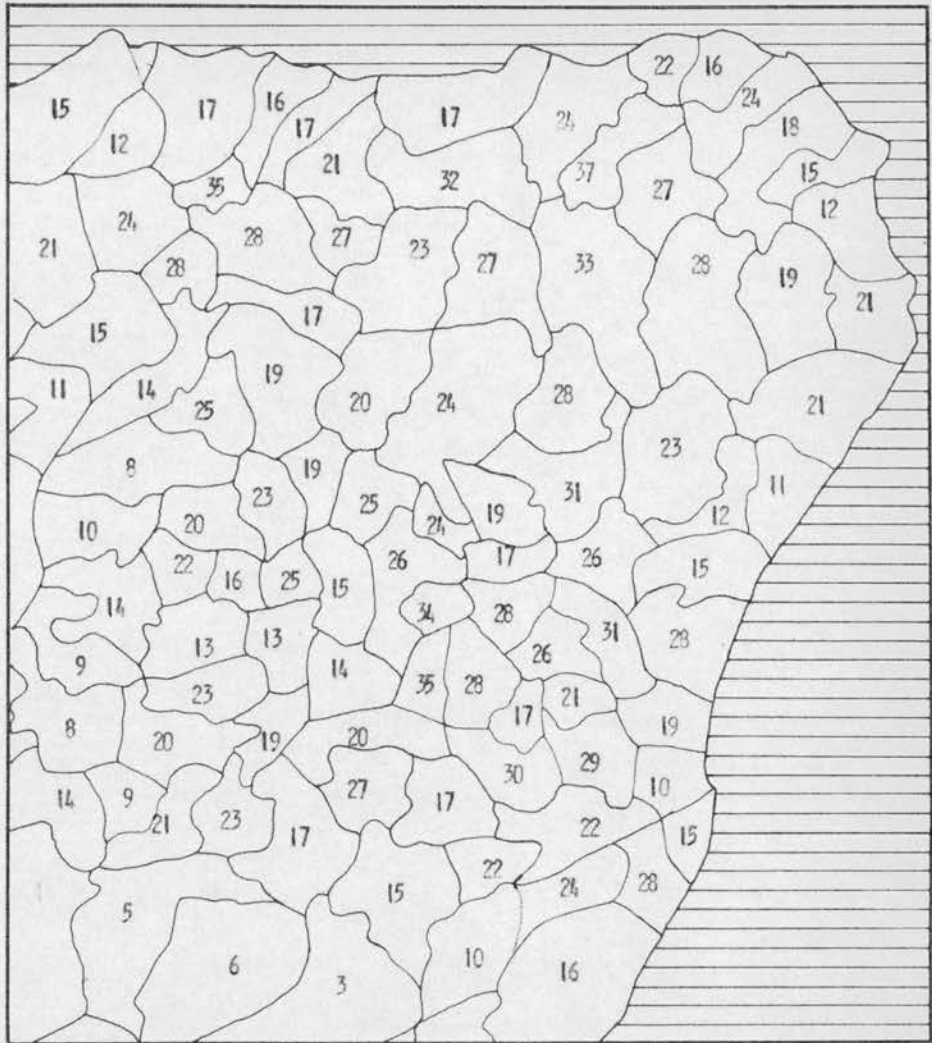
Figure 37.

Section Two- the pattern of numbering adopted, showing the parishes ordered roughly in lines and their location on the grid model.

to obtain a block stepped frequency surface. The results for the two sections used as samples, under the headings of number of holdings, crops and grass acreage, rough grazing acreage and number of fulltime male employees (20-65) are to be found in Figures 38 to 45 which follow. The others for the individual and total grain are used later in the examination of the patterns.

The result is a characteristic unit area representation. Where the projected profiles hide lower block profiles behind, other views may be taken and a stepped frequency surface constructed so that the hidden areas are visible. Those parish unit area values hidden even from a different perspective are found nevertheless on the accompanying key map. The rough grazing unit areas were viewed from the northeast to obtain a view of the arable lowlands in front with the wall-like rough hill country behind (Figures 40 and 44). Both give a sharply delineated block model of the real landscape completely in accord with the reality.

The surfaces may be smoothed into a curved trend surface. However smoothing obliterates a good deal of the pattern and in part the new profile hides even more low values than the stepped block surface. Part of each section could be singled out for an example of a stylized bell-shaped trend surface. The total result of either the stepped or smoothed surface is a valuable model where data is retrievable as long as the unit area numbered key map accompanies the model.



1 unit = 5 mm² or 14.7 sq. Kms

(1:625000)

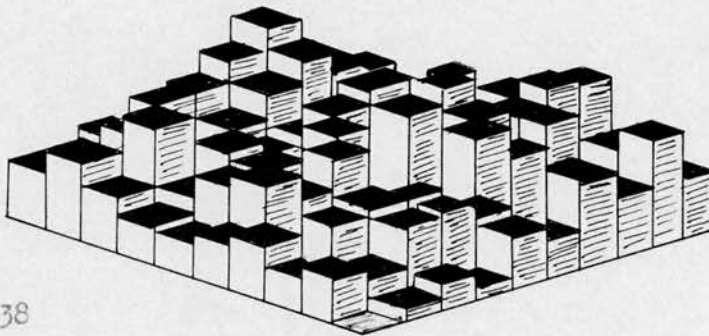
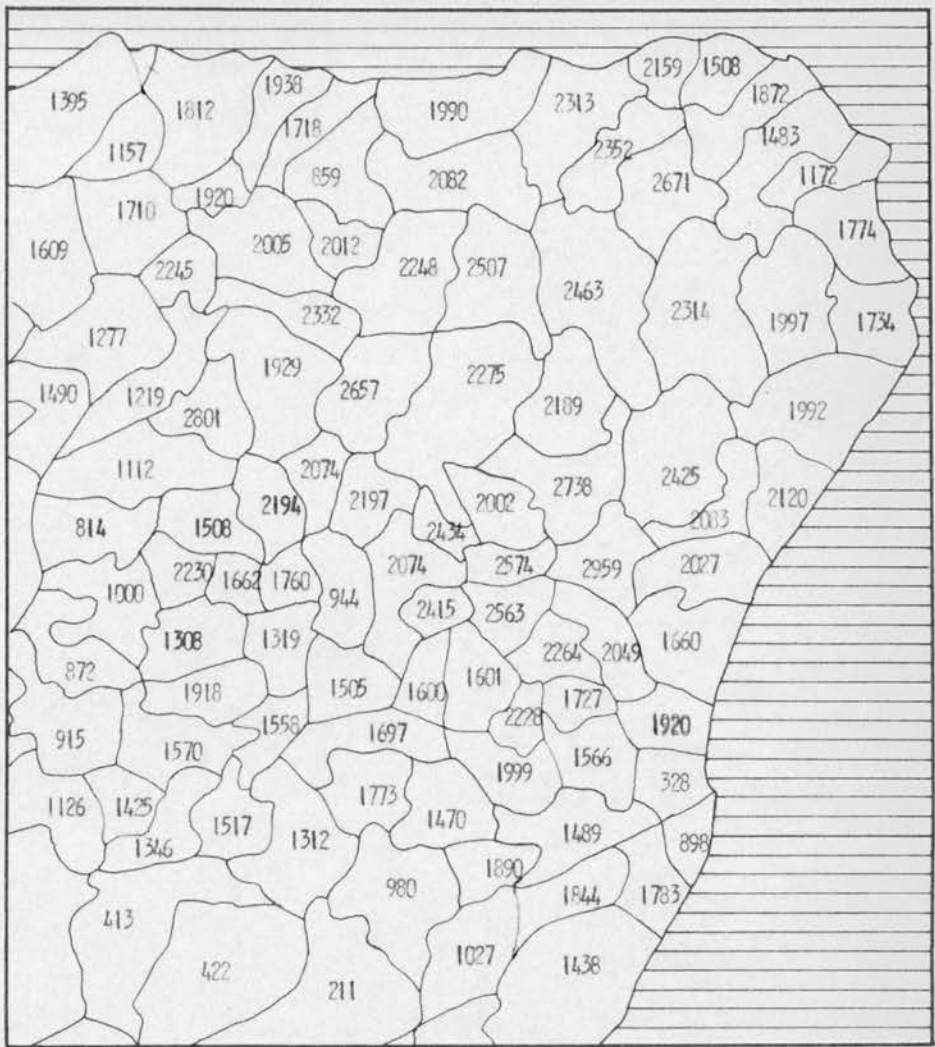


Figure 38

Vertical scale= 1mm. : 2 holdings

Number of holdings reported per unit area
in 1966



1 unit = 5 mm² or 14.7 sq. Kms

(1:625000)

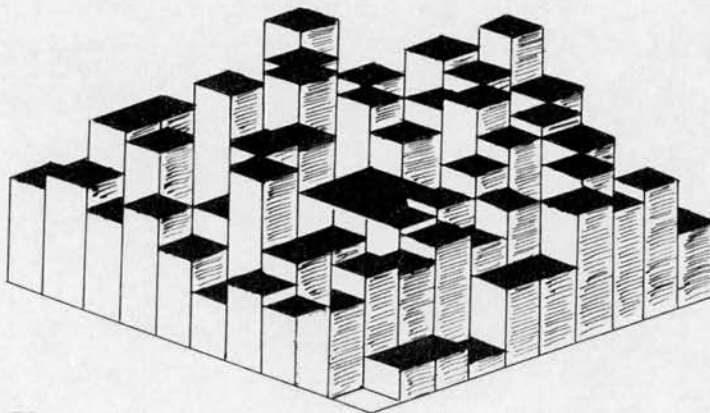


Figure 39

Vertical scale- 1 mm. : 100 acres

Crops and grass acreage per unit area in 1966

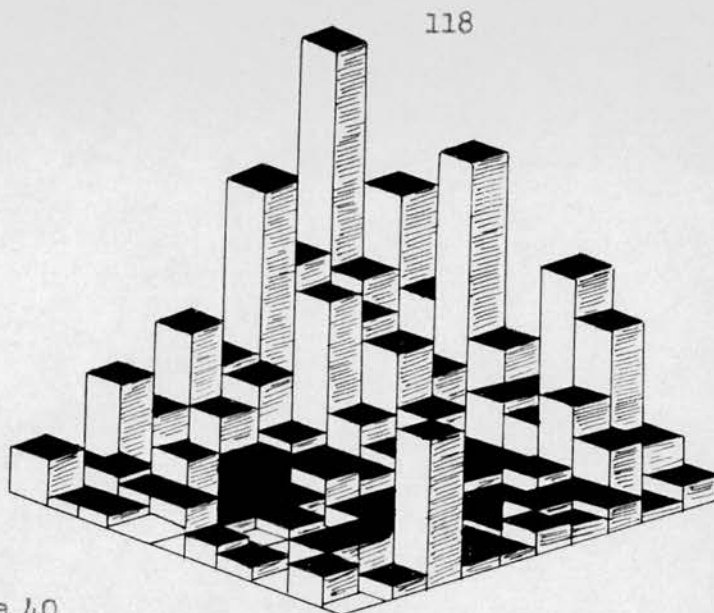
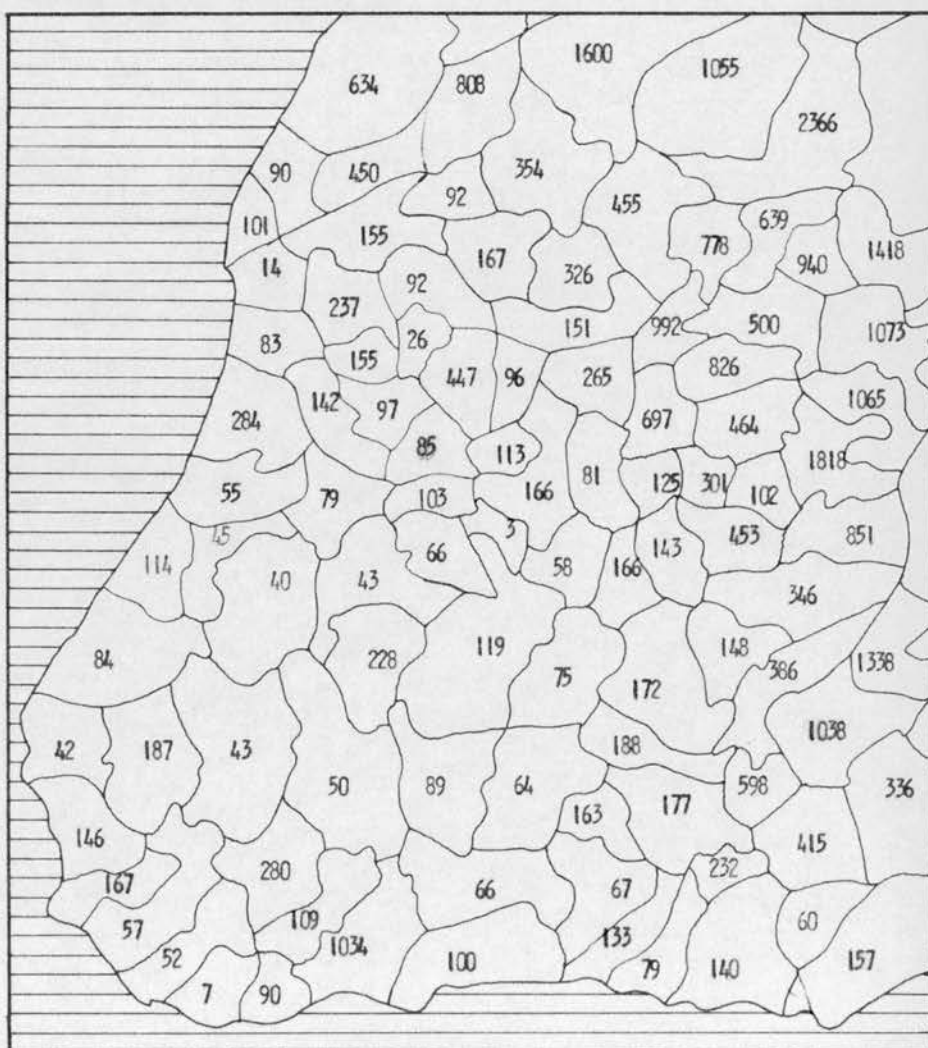


Figure 40

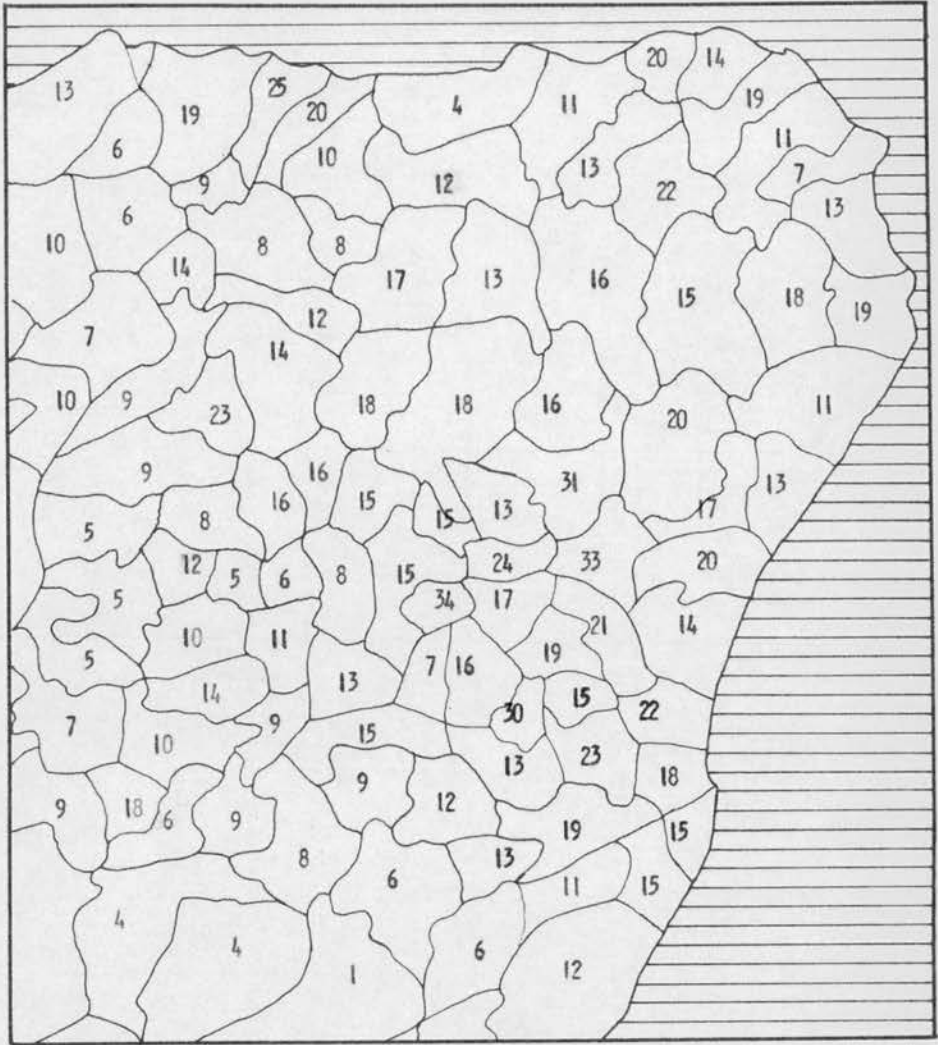
Vertical scale- 1 mm. : 50 acres

1 unit = 5 mm² or 14.7 sq. Kms

(1:625000)



Rough grazing acreage within the farm
unit per unit area in 1966



1 unit = 5 mm² or 14.7 sq. Kms

(1:625000)

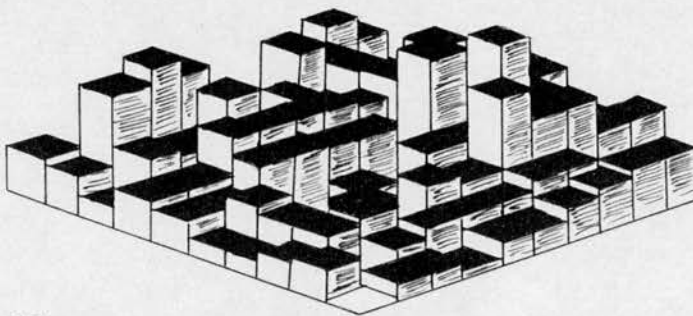
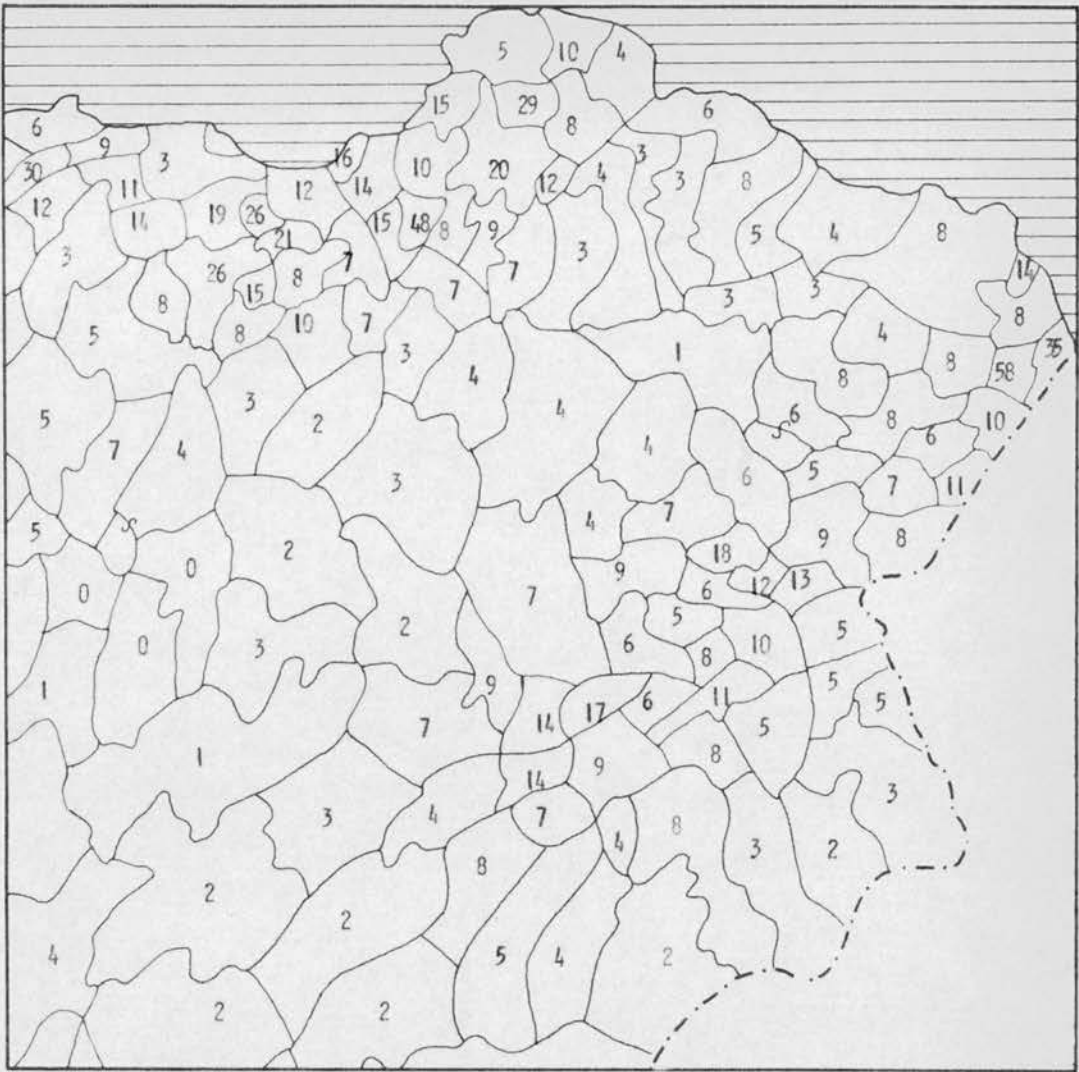


Figure 41

Vertical scale - 1 mm. : 2 men

Number of fulltime males (20-65) employed
per unit area in 1966



1 unit = 5 mm² or 14.7 sq.Kms

(1:625000)

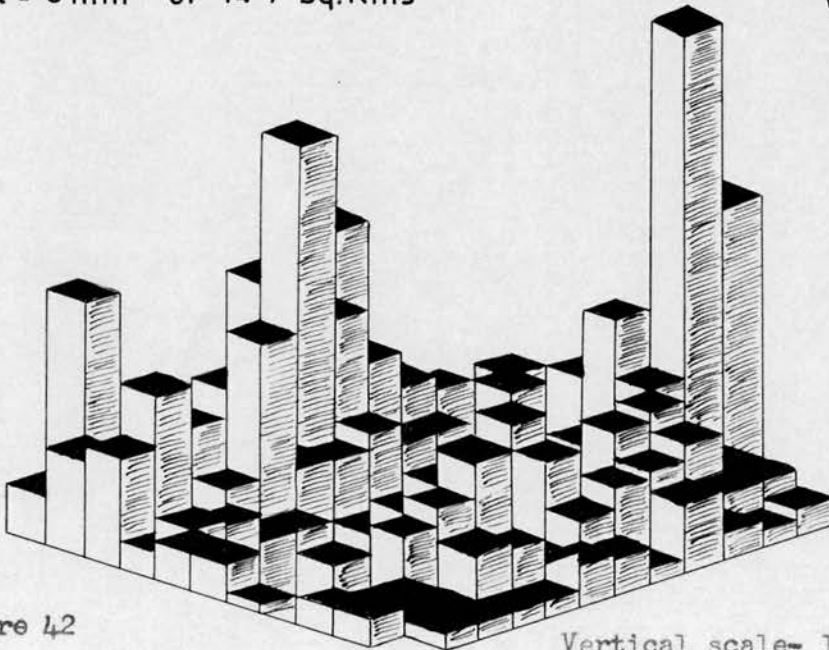
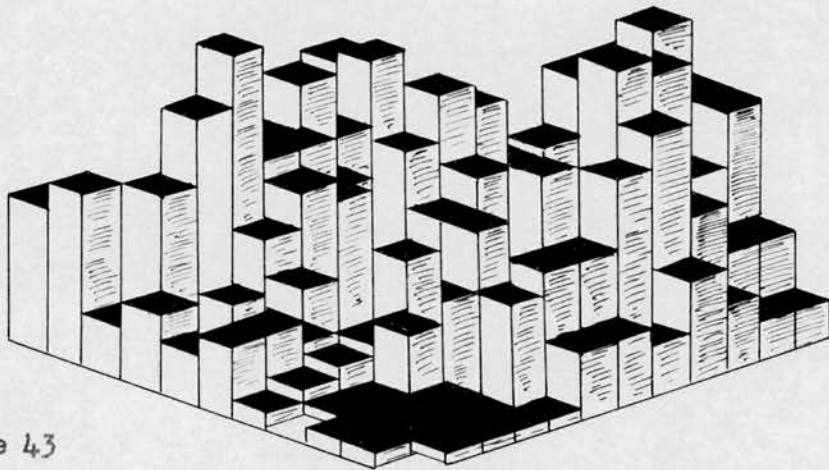


Figure 42

Vertical scale- 1mm : 1 holding

Number of holdings per unit area in 1966

(1:625000)



Vertical scale- 1 mm. : 100 acres

Crops and grass acreage per unit area in 1966

Acres of rough grazing per unit area in 1966

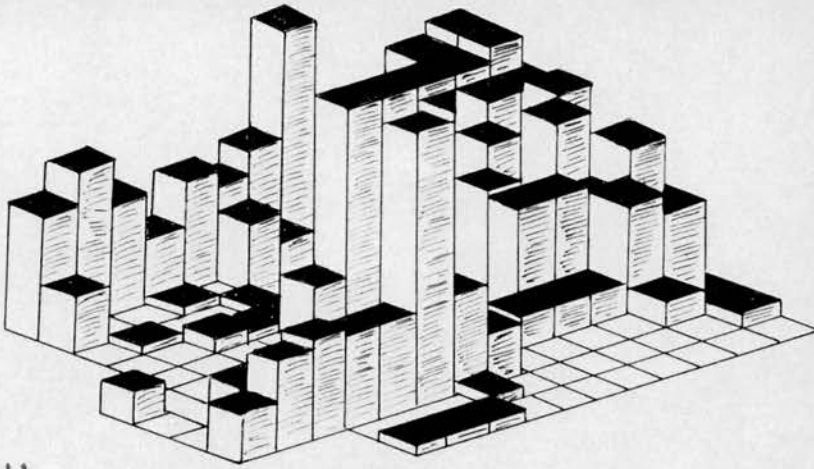
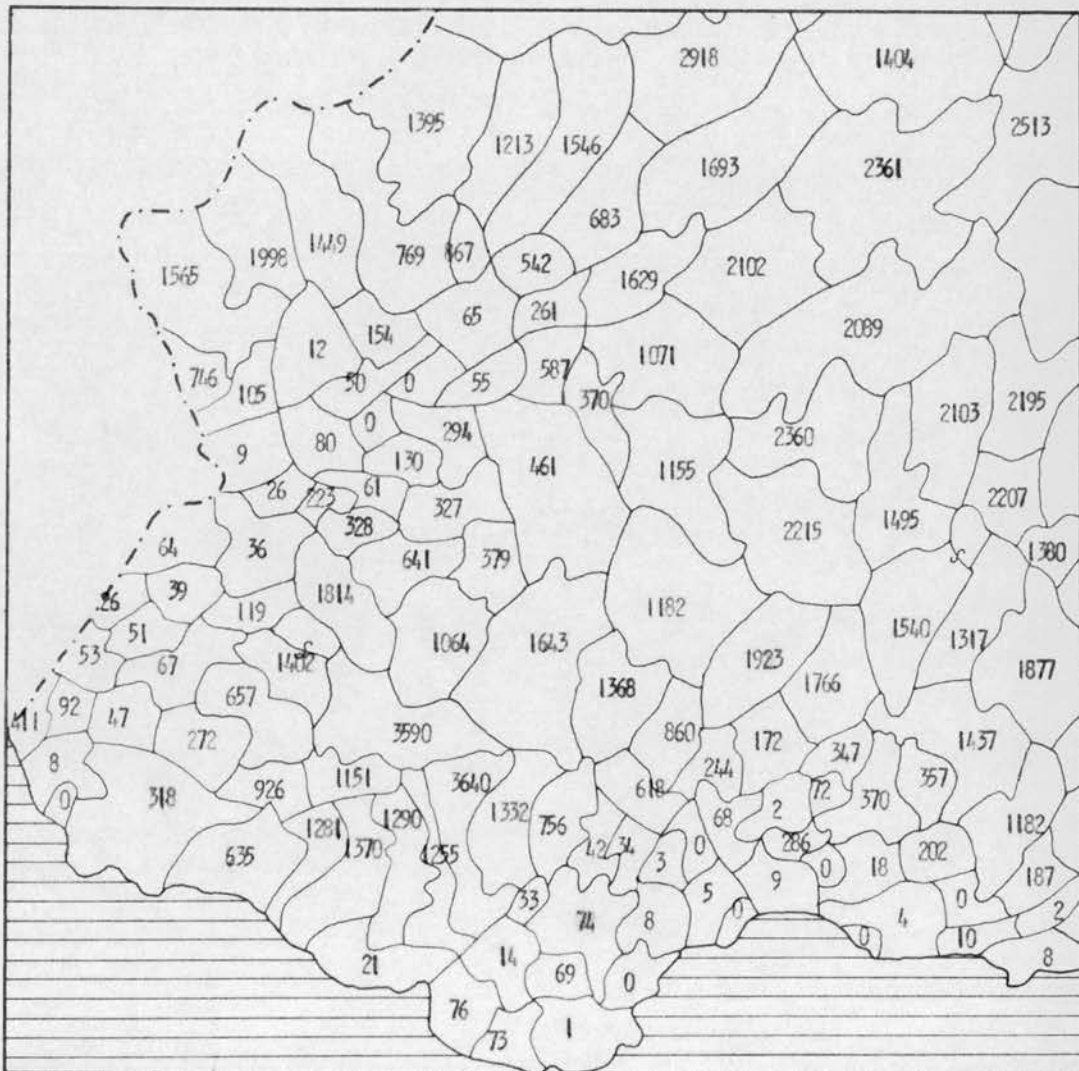


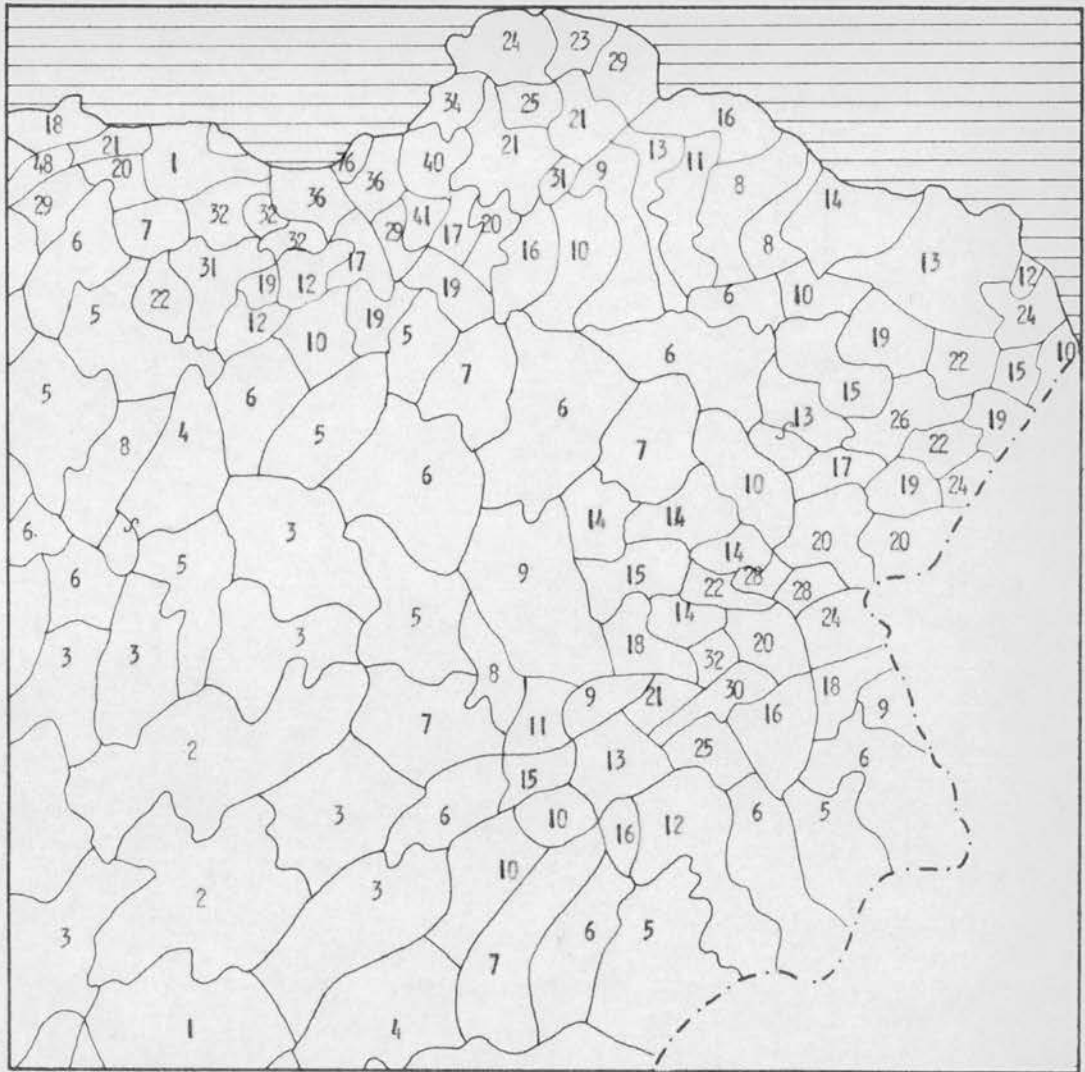
Figure 44

Vertical scale- 1mm. : 100 acres

1 unit = 5mm² or 14.7 sq. Kms

(1:625000)





1 unit = 5 mm^2 or 14.7 sq. Kms

(1:625000)

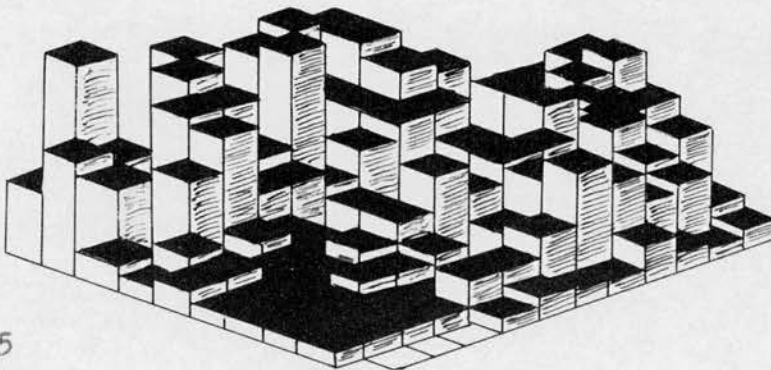


Figure 45

Vertical scale - $1 \text{ mm.} : 2 \text{ men}$

Number of fulltime males (20-65) per unit area,
in 1966

Unit Area Block Model of Scotland

Another model for unit area relationships was prepared for the entire country. The 1:625,000 scale parish map of Scotland was used as a base, a millimetre grid applied over it as before and the number of 5 millimetre squares determined for 270 parishes in the arable areas. The statistics for total grain acreage in these parishes in 1966, was divided by the number of 5 millimetre squares in each parish to obtain a unit area figure for grain. This figure is represented on the model at the vertical scale of one centimetre to 1000 acres. Blocks were cut and affixed to the map surface and it was found that 270 could be accommodated in the limited lowland space. Very large upland parishes and those with mixed features of both lowland and upland surfaces, are not represented since they contain a large area of non-arable land. When this occurred the characteristic unit area grain acreage proved too small to be modelled at the vertical scale chosen.

The result of this experiment was a unit area map comparing the characteristic grain patterns in each parish (Figures 46 and 47). While the parish based model favoured the output of large parishes (Figures 30 and 31, pages 105 and 106) since they towered over their smaller neighbours, the unit area map gives a better expression of grain concentration in the smaller highly arable parishes. The unit area map model gives accurate prominence to high value patterns in eastern Midlothian and neighbouring parts of Forth coastal East Lothian and to the Merse of Berwick.

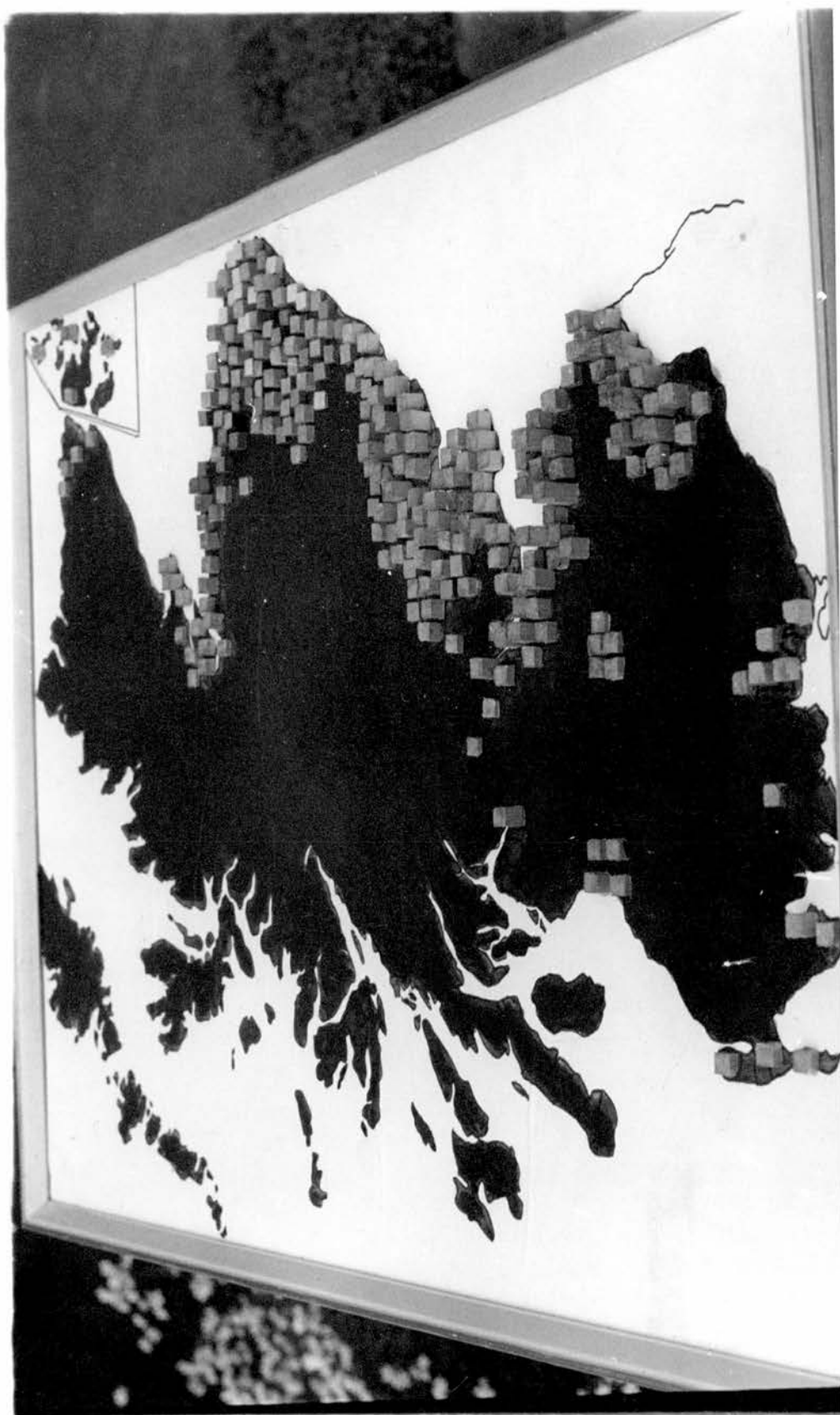


Figure 46

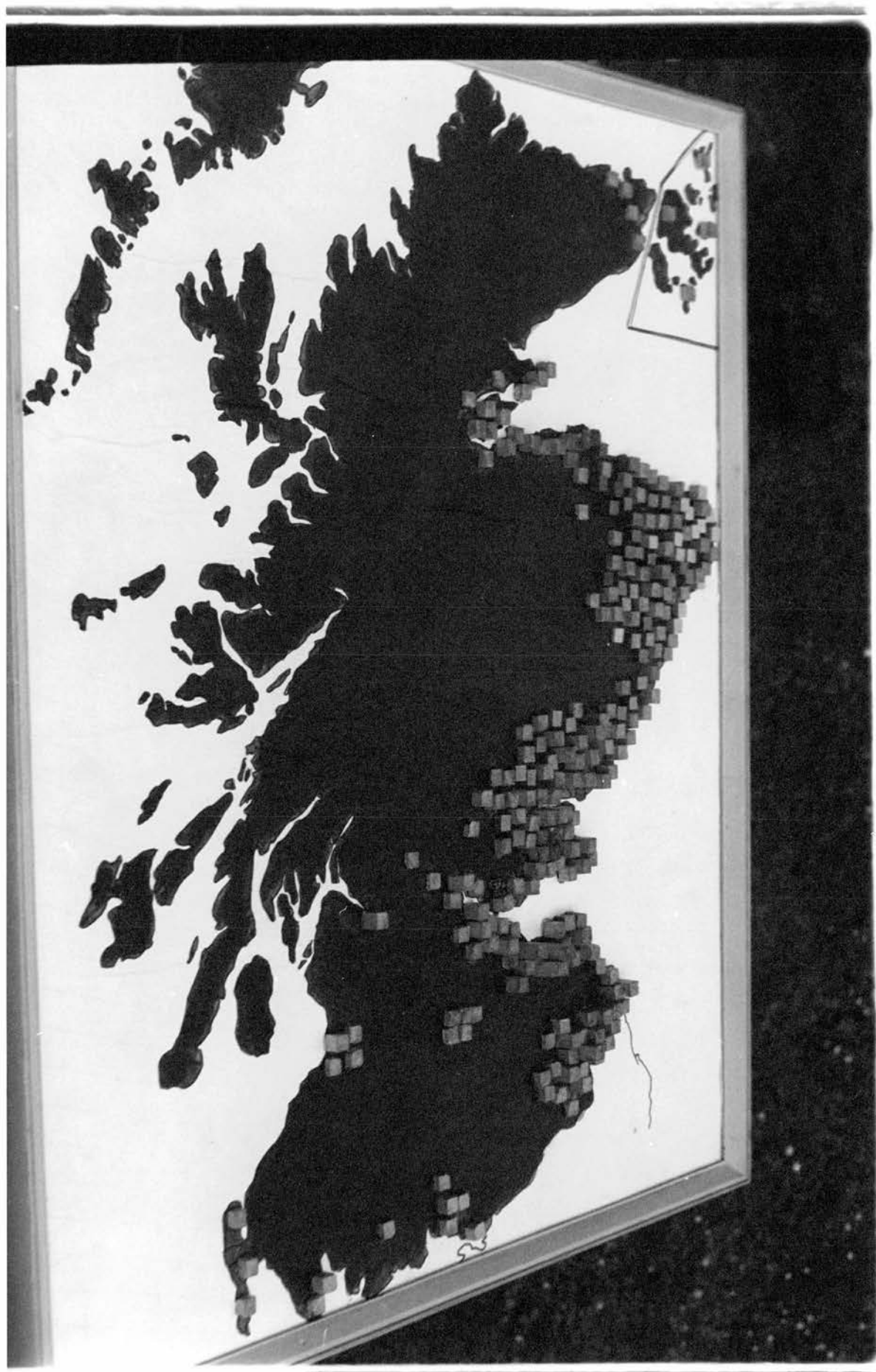


Figure 47

On the parish based map where the base areas differ so widely, emphasis was on the large arable parishes of Aberdeen as well as on the arable coastlands along the Moray, Tay and Forth Estuaries.

Unit Area Number Pattern Maps

Acreage number pattern maps similar to those prepared on the divided counties and counties' base (Appendix D) were prepared for the greater part of the two sample sections in eastern Aberdeen and south of the Forth Estuary. In these examples the number patterns represent percentages of wheat, barley, oats and total grain, and hundreds of acres of crops and grass characteristic to the unit areas. The parishes represented are named in Figures 48 and 50 and the unit area acreage number patterns presented in Figures 49 and 51. The multi-component, multi-dimensional contribution is the key value of the number patterns and the unit area basis offers areal comparability. The relationship of concurrent activities is not well expressed in the raised statistical surfaces unless a variety are presented on one page or in rapid sequence.

Conclusion

The fixing of a fine grid on the parish map of Scotland, the determination of the relative area values by a very small squared unit (such as a millimetre) and the division of the basic statistical data into unit area values provides an excellent degree of unit comparability. It is a simple process and until statistical material is collected on a national grid basis and

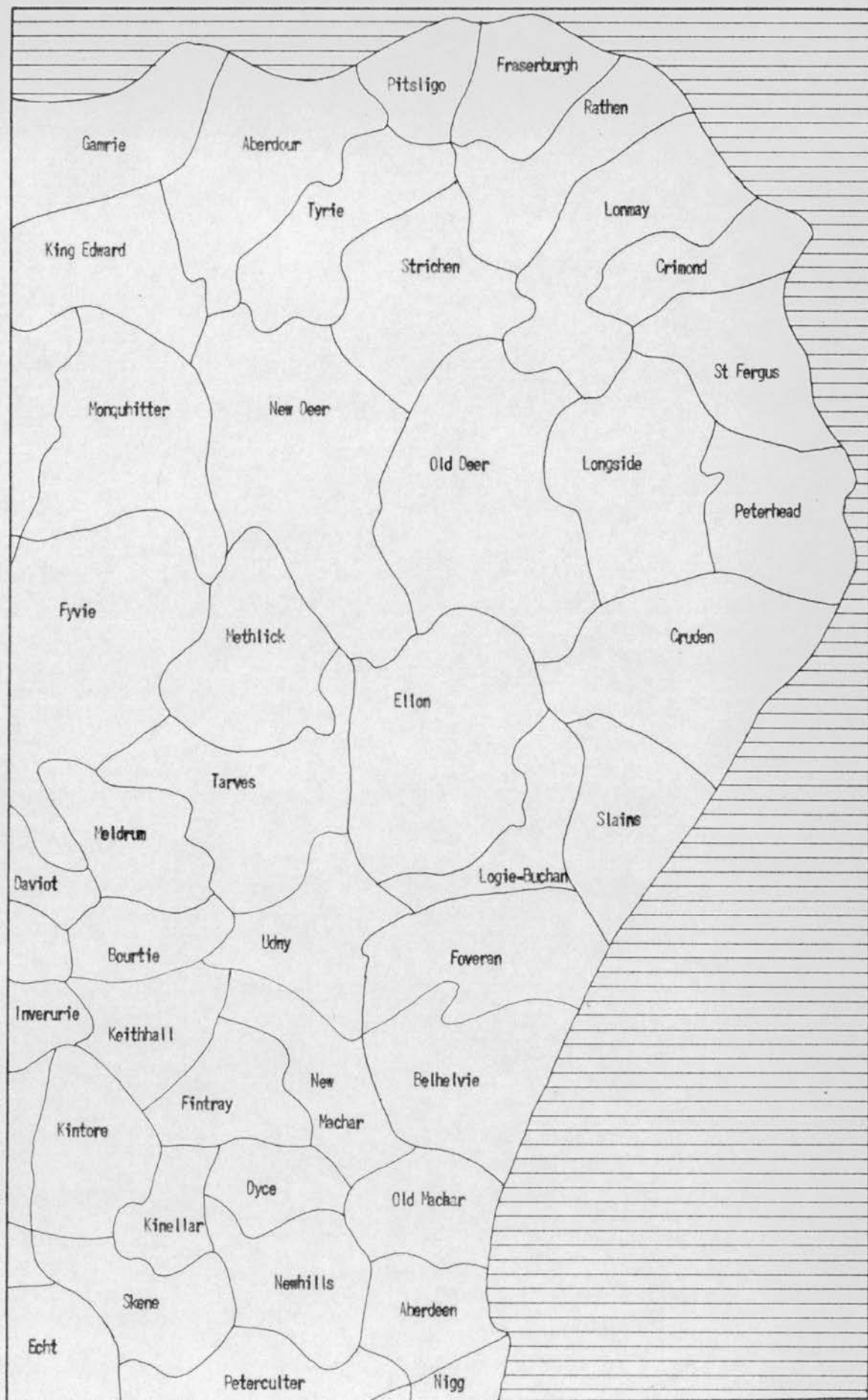


Figure 48.

Part of Section One- Aberdeen giving the names of the parishes for which number patterns have been devised on a unit area basis.

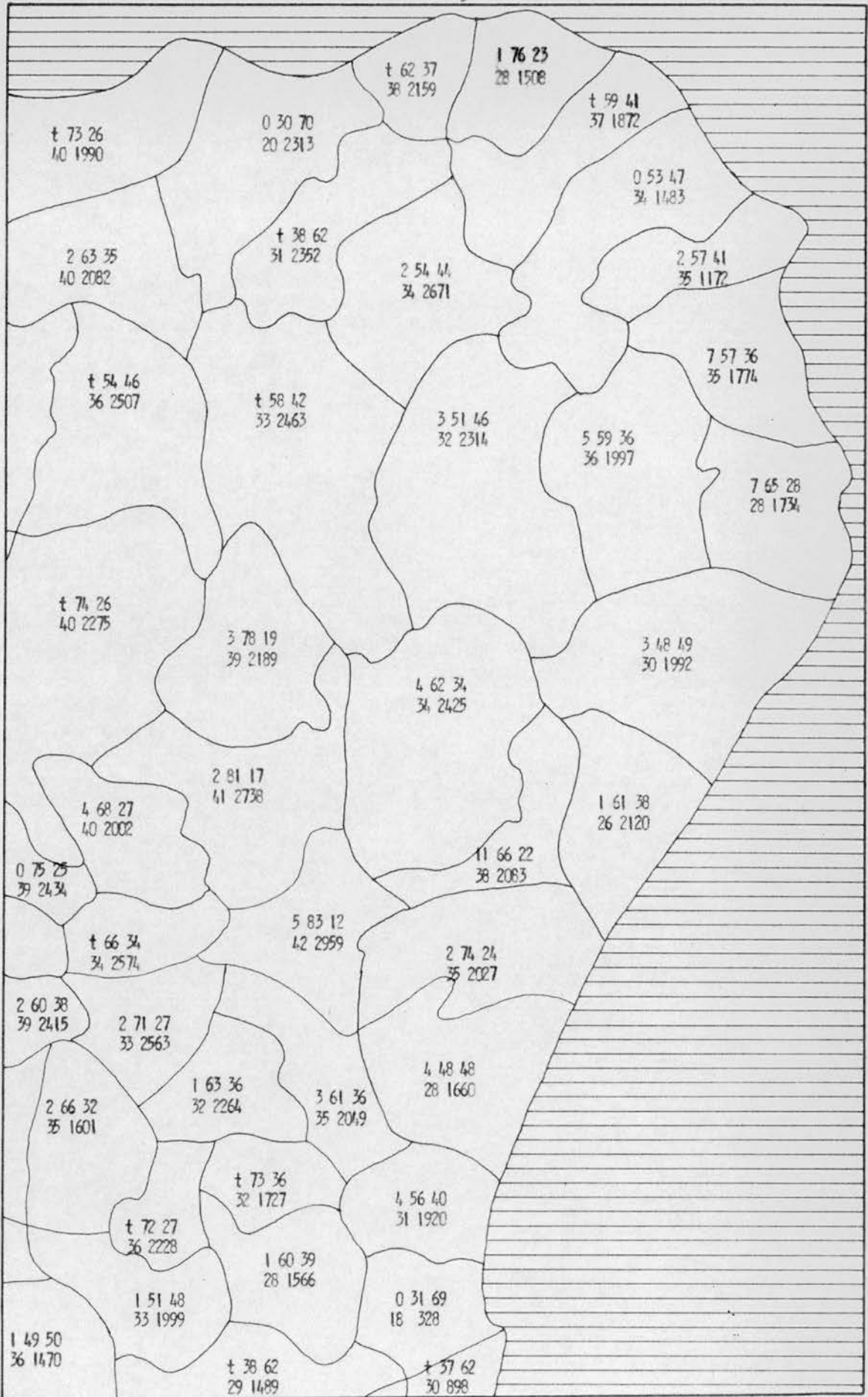


Figure 49.

Part of Section One-Acreage Number Patterns. The percentage of land in grain occupied by wheat, barley and oats per unit area of 14.7 sq.kms. is shown in the top line. The percentage of crops and grass acreage devoted to grain, and the actual crops and grass acreage per unit area of 14.7 sq.kms. is shown in the second line.

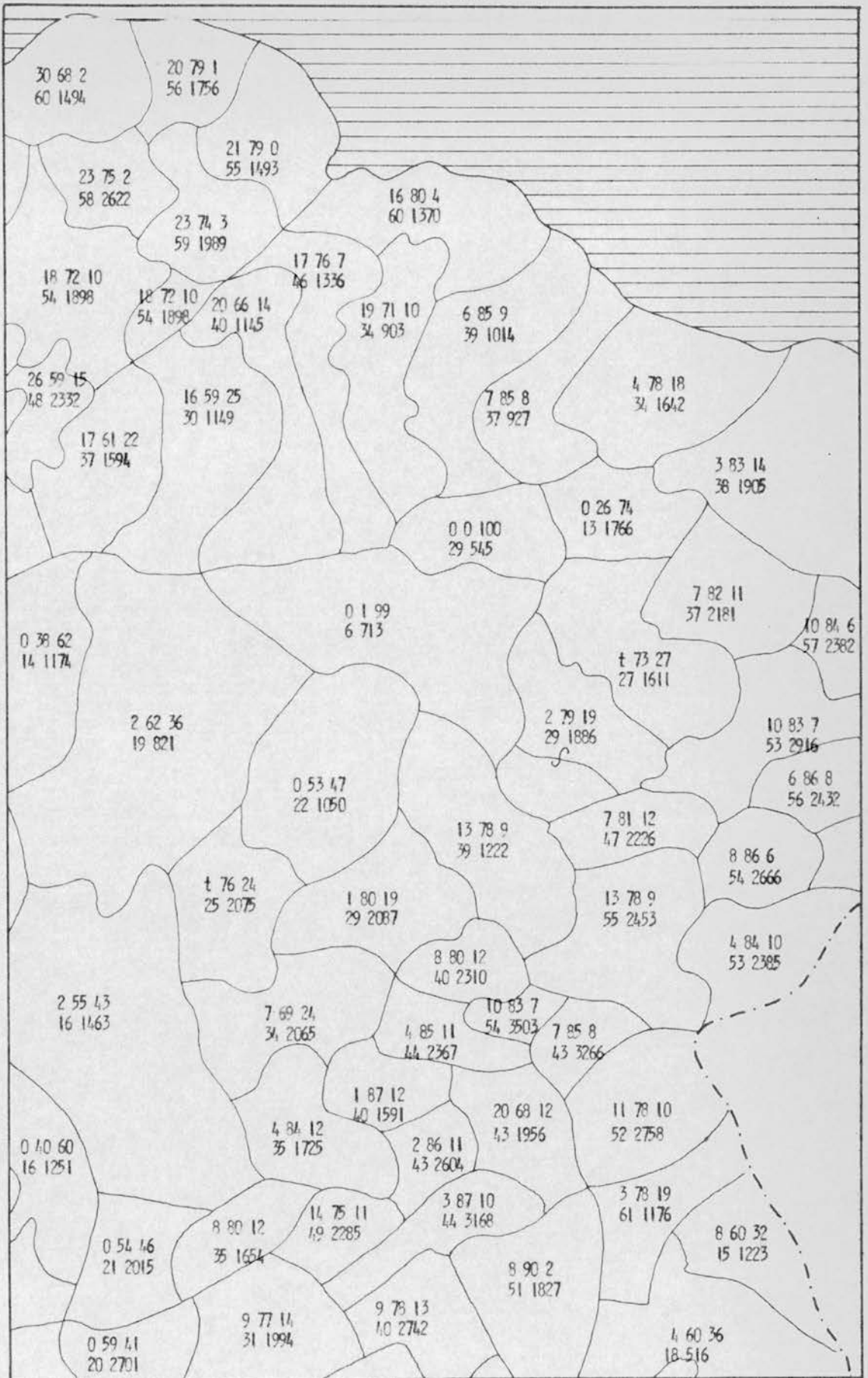


Figure 51.

Part of Section Two-Acreage Number Patterns. The percentage of land in grain occupied by wheat, barley and oats per unit area of 14.7 sq. kms, is shown in the top line. The percentage of crops and grass acreage devoted to grain, and the actual crops and grass acreage per unit area of 14.7 sq. kms is shown in the second line.

relatable to specific areas on the ground, offers the most striking results of the representational methods attempted. The surface patterns may be refined still further in detailed parish, sub-county or county based studies by excluding all non-croppable land after thorough field work. The data should then be applied on a unit area basis only to the parts of the area studied where crops may be grown. The reverse process may be applied if the chief economy involves the non-croppable area. If the population refers to industrial, housing, commercial or other subjects for which data may be collected, the unit area approach may be confined to the appropriate areas. Even the somewhat more generalized unit-area-per-parish approach yields far more valuable representational raised statistical surfaces than is possible in other methods. While a numbered key map accompanies the models there is a measure of data retrievability. The numbered key maps may also be shaded to provide sound unit-area-based density maps. All of the maps used as illustrations in this research would have been drawn on the unit basis, if a steady advance of methods had not been desired, leading to the most outstandingly striking representation on the country-wide basis.

PATTERNS OF DISTRIBUTION

Introduction

The purpose of this section is to survey the original parish, county and country statistics; demonstrate the applicability of the methods of representation to the real situation through a century of Scottish Agricultural Statistics ending in 1966; and present the patterns which have developed as clearly as possible. There is no intention to attempt an agricultural history of the development of grain farming in Scotland.¹ The representational material offered speaks more intimately than prose and there are already a variety of very good historical accounts in up to three Statistical Accounts by Scottish Counties, a wealth of papers and books reaching back into considerable antiquity,² detailed studies of individual areas,³ one land use survey and another in progress and a variety of good general accounts.

1. A variety exist such as Franklin, T.B., *A History of Scottish Farming*, Nelson, London 1952, Handley, J.E., *Scottish Farming in the 18th Century*, Faber, London, 1953, Handley, J.E., *The Agricultural Revolution in Scotland*, Burns, Glasgow, 1963 and Symon, J.A., *Scottish Farming, Past and Present*, Oliver and Boyd, Edinburgh 1959.

2. Excellent general references including factors affecting Scotland are found in; Chambers, J.D., and Mingay, G.E., *Agricultural Revolution, 1750-1880*, London 1966, Deane, P., and Cole, W.A., *British Economic Growth 1688-1959*, Monograph 8, Cambridge university, Department of Applied Economics, Cambridge 1964, Nash, E.F., *Agricultural Policy in Britain*, University of Wales Press, Cardiff, 1965, Tracy, M., *Agriculture in Western Europe, Crisis and Adaptation since 1880*, Cape, London, 1964, and Orwin, C. and Whetham, E.H., *History of British Agriculture 1846-1914*, Longmans Green, London, 1964 as well as others.

3. There are more detailed studies with considerable agricultural content by such regional experts as; Cruickshank, J.B., *The Black Isle, Ross-Shire*, *The Scottish Geographical Magazine*, 77(1) April 1961 pp. 3-14, Darling, F.F., *West Highland Survey*, Oxford University Press, London 1955, Moisley, H.A., *The Highlands and Islands, A Crofting Region?* Institute of British Geographers Trans. 31, 1962 pp. 83-95, and Turnock, D., *Farming Patterns in Lochaber*, Inst. of Brit. Geogs. Trans. 41, 1967 pp. 145-158 as well as a great many others.

Regional characterizations of Scotland's ability to grow crops have been offered by Snodgrass¹ who has also provided an economic regional map of Scotland.² The Types of Farming, Land Classification and Land Utilisation Maps of Scotland³ offer another base and the Second Land Use Survey is in the initial stages⁴ of providing a more recent detailed assessment. Further historical studies are needed on a systematic basis on areas smaller than the county in some cases down to intimate land use studies on certain estates or farms where records are available.

In general, the patterns of distribution of grain in Scotland over the century 1866-1966 depend on a variety of factors from the influences of war to rotational practices on the farm. War has been responsible for the creation of two great peaks of production which reached their heights in 1918 and in 1942-43. The artificial demands of war seem to have had the most disturbing influence, matched only by the depth of the pre-war and post-war slumps. Governmental changes of policy offer incentives or dis-incentives that

1. See Snodgrass, C. P., The Influence of Physical Environment on the Principle Cultivated Crops of Scotland, Scottish Geographical Magazine 48(6) November 1932 pp. 329-347, and the unpublished doctoral thesis by the same author, The Influence of Physical Environment on Agricultural Practice in Scotland, University of Edinburgh 1931.

2. Snodgrass, C. P., Map of Economic Regions of Scotland, Scottish Geographical Magazine, 59(1) April 1943 pp. 15-18.

3. These maps were published in 1944 and 1945 by the Ordnance Survey, HMSO and were the result of the first large scale land use survey of Great Britain compiled by the Land Utilisation Survey of Great Britain in conjunction with the Department of Agriculture for Scotland.

4. Coleman, A., The Second Land Use Survey: Progress and Prospect, Geographical Journal 127(1961) pp 168-186.

affect the patterns. The Crofting Act ensures a certain grain acreage even in areas of poorer land¹ and very low yields as long as labour is available. Local market patterns have less influence in recent years as far as grain farming is concerned although local traditions are still important. New grain varieties have helped produce a sharp change in crop patterns in the last decade or so and have enabled Scottish farmers even in some of the remote areas to attempt to respond to international market needs, notably in the recent demand for high quality barley. The climate influences cropping patterns, where overly wet or dry, or cold or hot growing seasons alter the yields. On the macro-scale even very harsh years do not influence grain farming quite as severely as livestock farming, especially over severe winter conditions such as experienced in the dreaded winter of 1879. The grain varieties in use resist a great variety of conditions with considerable success. Although farm labour is scarce and mechanization has replaced the horse, the efficiency of grain cultivation has not been impaired even when the owner/operator may have to operate the enterprise on his own. As far as grain growing is concerned mechanization has led to improved intensive land use and to specialization in crops which require the least human labour. Even the usual course of rotation and changing field use about the farm, helps explain fairly large fluctuations from one type of grain to another, of several hundreds of acres on the parish basis.

¹. A discussion of reclamation grants for improving land and a recommendation that such grants be made available for the improvement of grassland, is to be found in pages 14-19 in a report by the Advisory Panel, Department of Agriculture and Fisheries for Scotland, Land Use in the Highlands and Islands, HMSO, Edinburgh 1964.

Although all of these factors influence the patterns of distribution of grain, some lead to minor and more local fluctuations which may be surveyed in more intimate detailed studies of small areas. On the macro-scale the major influences producing striking patterns have been the changing international situation represented in spontaneous artificial pressures to produce stimulated by war, or changes in governmental policy concerned with the same, the development of new, more adaptable grain varieties and the trend to farm mechanization which grain farming encourages and the decreasing availability of labour intensifies. These general factors are seen most often in the patterns of distribution covered in this survey.

General Historical and Political Patterns

1. The continuation of prosperous production (which began in 1849)¹ during the American War of Secession 1861-1865, which delayed the entry of grain imports to the British market from the United States of America and the Franco-Prussian War 1871-1873 which stimulated the demand for British grain in the European market. These events served to prolong the period of prosperity for British farmers.

2. The decline in grain production began in the mid-1870s when cheaper grain began to reach Great Britain in volume from North America and elsewhere in the New World.

1. A detailed paper providing a valuable summary of these factors is that of Egerer, G., *The Political Economy of British Wheat 1920-1960*, Agricultural History, University of California Press 40(4) October 1960 pp. 295-310. Other historical references were listed in footnote 2 on page 133.

"The machine aided production in the United States of America alone increased from 292 million bushels in 1875 to 602 million bushels in 1900"¹ Further production entered the market from Canada, Argentina, Australia, Russia and other countries. British production declined to 1915.

3. The considerable increase in acreage and production achieved during the war of 1914-1918 halted the decline in grain growing and demonstrated the ability to grow crops in times of national stress. Although the increase was not sufficient to meet the needs of the country, it provided a measure of peak acreage patterns.

4. The Corn Production Act 1917 established minimum prices for 1917-1922 and minimum wages for agricultural labour. In 1920 a guarantee was added to the Agriculture Act 1920, in the form of a parity whereby the minimum price of wheat was to be the ratio of wheat prices to wheat costs in the "standard" year 1919. However a fall in prices in 1921 led to the repeal of the parity principle of 1920 and a return to free enterprise. The act was meant to encourage the production of wheat and oats, but did nothing for barley, consequently barley acreages dropped in many areas. When the minimum supports were allowed to fall and maximum prices of wheat were fixed, the result was to discourage domestic production.

1. See page 77 in World Agriculture, a publication of the Royal Institute of International Affairs, Oxford University Press, London 1932. Fonblanque, A.W., Agriculture Statistics for Great Britain, 1868 on page 16 listed Scotland's acreage beside those of U.S.A. and Great Britain as a whole to provide an effective illustration of the situation a century ago.

| 1868 | Crop | Scotland | United States | Great Britain |
|----------|--------|-----------|---------------|---------------|
| Acreages | Wheat | 124,683 | 18,459,779 | 3,688,357 |
| | Barley | 219,515 | 937,498 | 2,251,480 |
| | Oats | 1,011,430 | 9,665,736 | 2,782,720 |

5. A chaotic period in the 1920s and the depression in the early 1930s led to the abandonment of the free trade policy and further government action in the Wheat Act 1932. A light tariff imposed against non-domestic wheat and a subsidy guaranteed farmers prices up to a maximum production of 27 million hundredweights a year, less and allowance for seed and waste. The result was an expansion of domestic acreage and output. As world prices improved the subsidy fell. Consequently the Agriculture Act 1937 provided no subsidy but raised the maximum production from 27 to 36 million cwts. In 1939 all restrictions on output were abolished and the Grassland Ploughing Subsidy offered £2 per acre for ploughing up land which had been under grass for 7 years or more.

6. A sharp increase in domestic production in response to the stress of war lifted British grain production from the low of 1939 to a peak in 1942 (in some counties in Scotland in 1943). The Marginal Agricultural Production Scheme 1942 was aimed at bringing land into tillage production which had been regarded hitherto as unsuitable for crops.

7. A domestic surplus of grain seemed to be imminent in 1945 and the government advocated more livestock production. A combination of bad weather and a sharp drop in wheat acreage helped lead to bread rationing in 1946 and it continued to 1948. The shortage of feed grains continued longer though the Agriculture Expansion Programme was designed to increase production by 50 per cent over pre-war and 20 per cent over 1946-1947 production.

Incentives by way of higher prices ,acreage payments and ad hoc subsidies and grants were announced to encourage increased efficiency, self-sufficiency and greater output.

8.The Agriculture (Scotland)Act 1948 conferred a greater security of tenure on efficient tenant farmers, and the Agricultural Holdings (Scotland)Acts 1949 provided freedom from fixed crop rotations¹ which had hitherto been required under the terms of farm leases.² Also in 1949 the First InternationalWheat Agreement was signed by Great Britain and led to a fixing of international prices within a stated range.

9. In 1952 acreage payments for older land ploughed for crops were re-introduced on a limited basis, and in 1953 grain import controls were abolished. Bread subsidies were dropped in 1956 and 1957. The Wheat Act 1932 was repealed.

10. In 1959 a new international wheat agreement was signed and the prospect of Great Britain entering the European Economic Community led to the postponing of decisions on matters affecting grain and other crops.By the end of the century 1866-1966 grain production was

1.A discussion of the 6 course rotation common in East Lothian and a 7 course rotation in Angus may be found in Meiklejohn,A.K.M.,South-Eastern Scotland Agriculture, Miscellaneous Publ.72,Edinburgh and East of Scotland College of Agriculture,1951,18pages.

2.Connell,C.G.,and Johnston,C.H.,The Agricultural Holdings (Scotland)Acts 1949,W.Hodge & Co.,Edinburgh,1951 page 53, Item (26)Sec.12,"No conditions can be imposed on a tenant by lease or otherwise,to prevent him from practising any system of cropping of the arable land or from disposing of the produce of the holding. These are now statutory rights and the tenant cannot be subjected to any penalty,for future or liability for exercising."

supported within a general system of agricultural production with emphasis on the raising of productivity and the reducing of the need for support prices.

CHANGING PATTERNS OF DISTRIBUTION IN GRAIN GROWING

It is possible to examine the aggregate statistics for Scotland as a whole and pick out key figures reached in certain years as examples of trough and peak production. If this approach is followed, useful information would be that wheat acreage reached its peak of 170,623 acres in 1943 and its lowest trough points in 1895 with 33,641 acres and in 1901 with 36,225 acres. The period when wheat acreage was less than 75,000 acres lasted from 1880 to 1932. Similarly, barley acreage was at its highest at 270,517 acres in 1881 in the first half of the century of statistics but the overall peak was at the end in 1966 when there were 665,431 acres. Barley acreage was less than 145,000 acres from 1926 to 1941. The acreage of oats fell to its lowest point in 1966 at 397,897 acres and fell below 900,000 acres from 1927 to 1939 and from 1953 to 1966. The peak acreage of oats was in 1918 when 1,243,823 acres was recorded and a second peak in 1942 with 1,158,263 acres. Rye production was at the high point of 10,087 acres in 1877 but fell below 5,000 acres in 1926 to a low of 646 acres in the last year when it was given as a separate category in 1961.¹

1. The rye statistics are not included with general grain totals since a generally undifferentiated amount of rye is grown chiefly for forage or fodder, and not for use as a cereal grain.

This sort of general information is not very satisfactory in revealing the pattern of grain distributions in Scotland. The national scale obliterates a great variety of changes of emphasis within the country and the use of quantities of raw statistics is more likely to intimidate than to inform.

Another approach might be to use the county as the basic reference unit and present statistics and maps on that basis. This approach is useful in fairly homogenous areas such as in parts of southeastern England where the counties are highly arable and include a comparative minimum of non-arable or rough land within their borders. In Scotland, the county is not a useful base for reference. Some counties are slightly more uniform than others and Nairn, Kincardine, Fife, West Lothian and Renfrew are fair examples. The county-based approach has been used recently ¹ and the result is that the very large highland-upland parts of Scottish counties are averaged with the more arable parts to present a wholly misleading map picture. Two sets of four maps based on percentage and acreage statistics have been prepared to show the changing degree of emphasis and accuracy when the county is used as the base unit, followed by the divided counties, grain regions and the parish (Figures 52 and 53).

¹ See the publication - A century of Agricultural Statistics, Great Britain 1866-1966, Department of Agriculture, HMSO, London 1968, 129 pages.

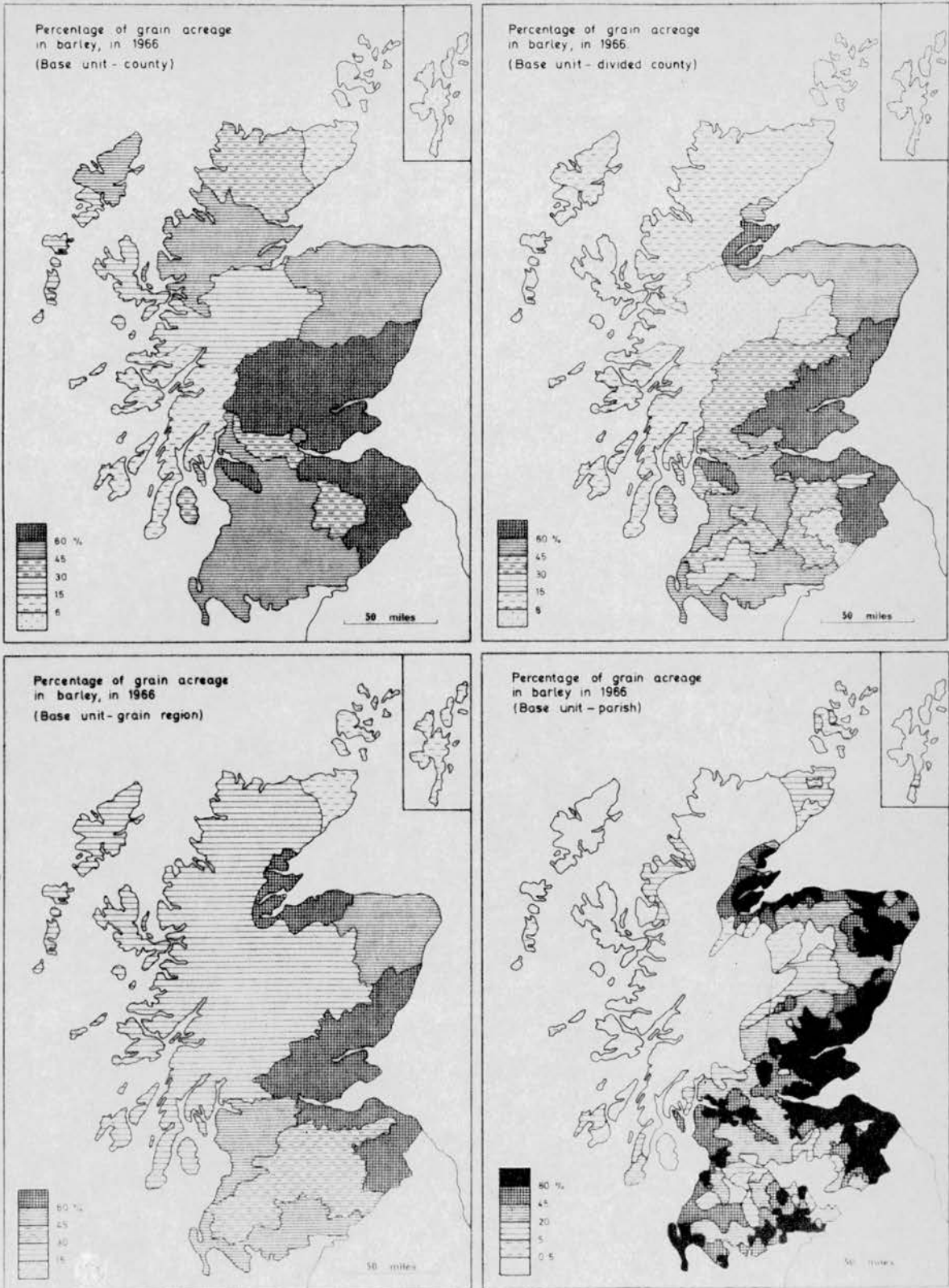


Figure 52

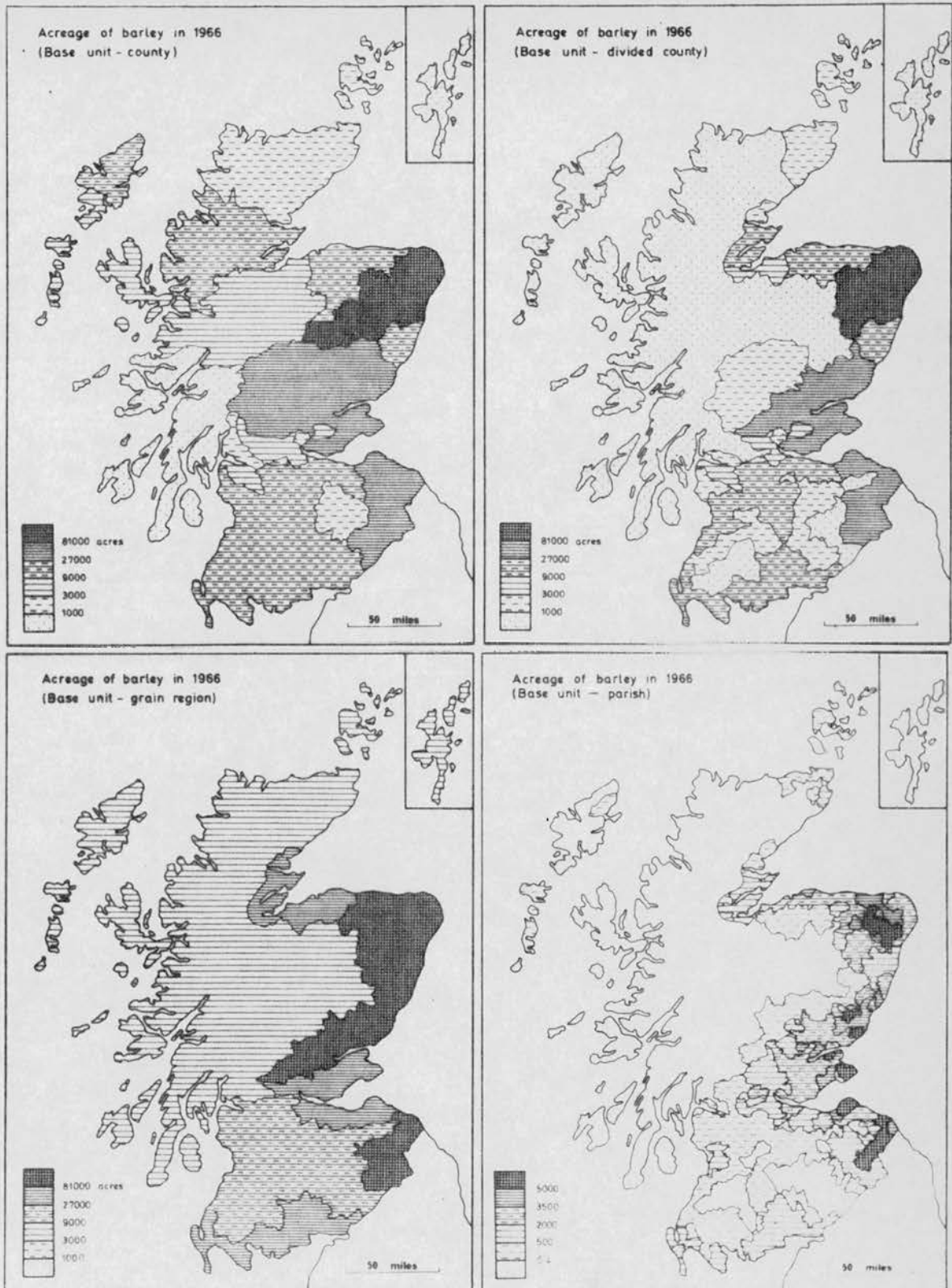


Figure 53

A table of statistics taken from about the middle of the century provides a useful example to show the absurdity of the county-based approach in Scotland. Aberdeen is used as an example.

| ABERDEEN ACREAGES 1915-1925 | | | | | |
|-----------------------------|-------|--------|---------|--------------------------|-----------------|
| Year | Wheat | Barley | Oats | Total Grain ¹ | Crops and Grass |
| 1915 | 59 | 16,888 | 194,557 | 211,504 | 626,519 |
| 1916 | 26 | 19,068 | 192,421 | 211,515 | 623,689 |
| 1917 | 43 | 19,646 | 193,796 | 213,485 | 627,879 |
| 1918 | 28 | 21,091 | 228,872 | 250,326 | 628,492 |
| 1919 | 16 | 23,240 | 205,562 | 228,818 | 627,541 |
| 1920 | 32 | 29,758 | 191,627 | 221,498 | 626,798 |
| 1921 | 37 | 23,382 | 191,748 | 215,168 | 627,420 |
| 1922 | 53 | 21,396 | 190,669 | 212,118 | 627,077 |
| 1923 | 30 | 21,995 | 187,362 | 209,427 | 626,630 |
| 1924 | 50 | 18,446 | 188,344 | 206,840 | 626,301 |
| 1925 | 0 | 20,033 | 183,608 | 203,691 | 625,557 |

The four large highland parishes of Glenbuchat, Strathdon, Crathie and Braemar and Glenmuick, which contained 9,947, 27,605, 174,073 and 44,519 acres of rough grazing land as reported in the census of 1960, may be regarded as the chief components of upland Aberdeen, more or less in one place. Together they make up nearly 66 per cent of the rough grazing land of the county and nearly 39 per cent of the land in farms. The Statistics for upland Aberdeen taken separately out of the above are given as follows:

| UPLAND ABERDEEN ACREAGES 1915-1925 | | | | | |
|------------------------------------|-------|--------|-------|-------------|-----------------|
| Year | Wheat | Barley | Oats | Total Grain | Crops and Grass |
| 1915 | 0 | 25 | 3,328 | 3,353 | 14,112 |
| 1916 | 0 | 25 | 3,372 | 3,397 | 14,088 |
| 1917 | 0 | 35 | 3,403 | 3,438 | 14,157 |
| 1918 | 0 | 22 | 3,960 | 3,982 | 14,060 |
| 1919 | 0 | 35 | 3,573 | 3,608 | 14,060 |
| 1920 | 0 | 80 | 3,381 | 3,461 | 14,050 |
| 1921 | 0 | 53 | 3,283 | 3,336 | 13,969 |
| 1922 | 0 | 52 | 3,261 | 3,313 | 13,978 |
| 1923 | 0 | 67 | 3,222 | 3,289 | 13,974 |
| 1924 | 0 | 53 | 3,189 | 3,242 | 13,891 |
| 1925 | 0 | 34 | 3,095 | 3,129 | 13,842 |

¹. Total grain here includes mixed grain but is not listed as a separate category. Rye is not included.

A comparison of the tables reveals that in the period none of the wheat was grown in nearly 40 per cent of the land area in farms. It is wrong to attribute any wheat to the upland part of Aberdeen in 1915-1925. At no time did upland barley acreage ever reach one half of one per cent of the acreage for more arable Aberdeen and oats and total grain were consistent at between 1 and 2 per cent and crops and grass 2 or slightly more per cent.

This type of relationship was found in the majority of Scottish counties throughout the century and the decision to divide the counties into more upland and more arable parts along existing parish boundaries was made very early.¹ As a result, statistics are attributed somewhat more nearly to the area of origin and not spread over wide areas where there is little or no representation. A variety of illustrative materials in graphs, diagrams and maps has been prepared to show the grain patterns and they are used in the following account at the appropriate places. Some of the material makes use of the divided county approach, some grain regions made up from them where patterns are similar, some are based on the parishes and finally the unit area parish approach is developed to give a reasonably reliable map diagram representation of the real situation on the ground.

1. The identity of the separated parish groups by lowland and highland-upland areas is given in Appendix A by the official parish numbers. The basis for division into regions and divided counties has been discussed in the section pages 27-39.

The Year by Year Coverage of Patterns

One hundred years of grain and related statistics are represented on a set of 54 graphs of 22 divided counties and 11 undivided counties. Since the reference base for these graphs changed steadily throughout the century some of the statistics for key years are entered directly on the graphs to help maintain a balanced relationship. Statistics in a rounded retrievable form are supplied on one hundred number pattern maps which give a year by year pattern of the distributions over the whole country at once by 54 units. The bulk of this representational material is intended for reference purposes and is found in the appendices. A number of average and more usual graph examples are discussed briefly as well as some of the number pattern maps. In both cases the coverage is from 1867 to 1966 inclusive. The initial year in 1866 was not quite so complete in categories besides wheat, barley and oats.

The Line Graphs 1867-1966

The graph for lowland Aberdeen (Figure 54) is representative of the average arable situation in the north-east of Scotland. The base reference line compares annual total grain acreage to a fixed acreage of crops and grass. The year 1914 was chosen because it was about mid-point of the century and was also a very low trough year. As a result a pattern was bound to develop on either side of it when acreages of grain and actual year by year crops and grass were plotted. For the first few years of the census, orders of magnitude of acreages were reported and a number of years went by before the estimates reached a more reliable figure.

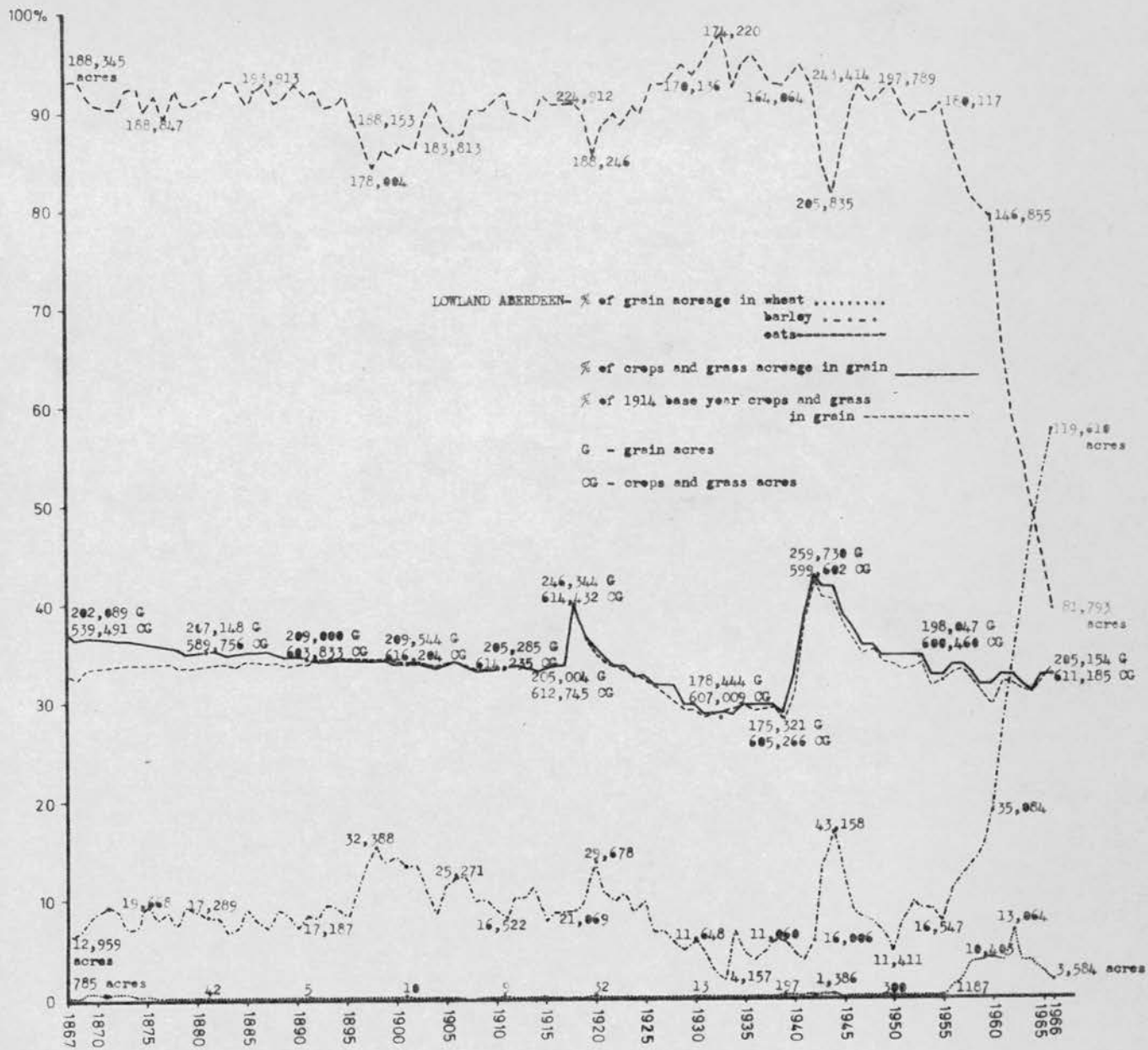


Figure 54

As a result most of the graphs show a marked divergence between the base line tied to 1914 crops and grass base reference and the actual line of year by year relationships, particularly in the first decade. In lowland Aberdeen the crops and grass acreage increased more rapidly than grain acreage until 1892. From 1892 to 1918 the rate of decline and then the increase of both lines kept pace. From 1919 to 1939, grain acreage fell more rapidly than the crops and grass but from 1939 to 1942 the grain increased sharply while the crops and grass base slowly decreased in acreage. From 1942 to 1966 grain acreage decreased from the 1942 peak while crops and grass slowly increased.¹ The end of the century in 1966 found grain acreage about average, much below the peaks in 1918 and 1942. The main change was in the components and the changing positions of oats and barley and the new strength of wheat in the graph patterns. More mention is made of these individual grain patterns in the sections devoted to them.

Generally wheat was not very important in lowland Aberdeen until 1955 when new varieties made possible a rise from a few hundred to over 13,000 acres between 1950 and 1962. Barley was more favoured from 1886 to 1909, 1912 to 1921, 1942 to 1946 and from 1956 to 1966, when the crop steadily replaced oats to become the most important grain after 1964. In order to show wheat, the individual grains had to be related to total

1. A discussion of the problems of applying official definitions of grass which is in "rotation" and that which is not, is given by Britton, D. K., and Hunt, K. E., on page 51 of Kendall, M. G., The Sources and Nature of the Statistics of the United Kingdom, Vol. 1, Oliver and Boyd, Edinburgh, 1952. Consequently some increases in crops and grass acreage may be the result of altered definition or interpretation rather than real increases.

grain to obtain a ratio percentage relationship. The oats line on the graph is therefore the least easy to read since the category is large and includes all that is left over after wheat and barley and an infinitesimal amount of mixed grain are subtracted from one hundred per cent. The superimposed statistics are useful but the full story is to be found in the number pattern maps (Appendix D).

The line graph for upland Aberdeen (Figure 55) follows a similar pattern in overall grain related to the fixed 1914 crops and grass and to the changing annual sequence. Clearly the limits to expansion in grain crops is more severe and there are no other alternatives to grain and grass as large scale cultivated crops. The peaks come in the same places but are not so extreme, especially in 1942, while fluctuations reveal a more sensitive reaction to year by year climatic changes since grain growing is a fringe activity to a much larger livestock raising industry.

The lowland Midlothian graph (Figure 56) is very typical of the better arable parts of counties in the southeast. There is some interchangeability of wheat, barley and oats patterns, in certain years, and relateable to the Fife and other Lothians patterns, and to a lesser extent to those in Berwick and Roxburgh. In the first 50 years crops and grass acreage increased rapidly then decreased slowly while grain acreage decreased slowly throughout. In the second 50 years the situation was reversed and crops and grass totals fell far more rapidly than grain despite the peaks in 1918 and 1942-1943. The most spectacular switch in roles of the three main grains has been

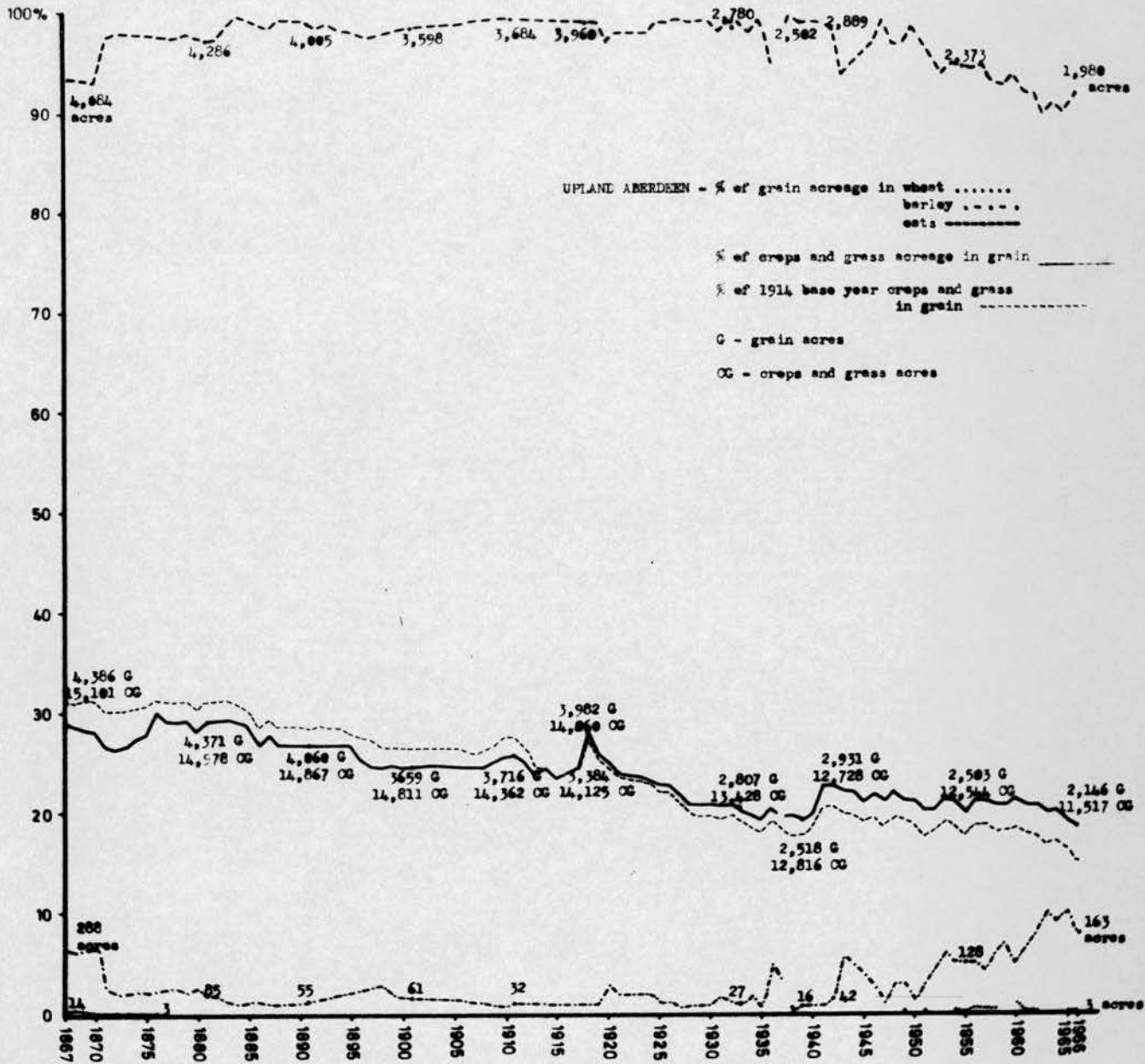


Figure 55

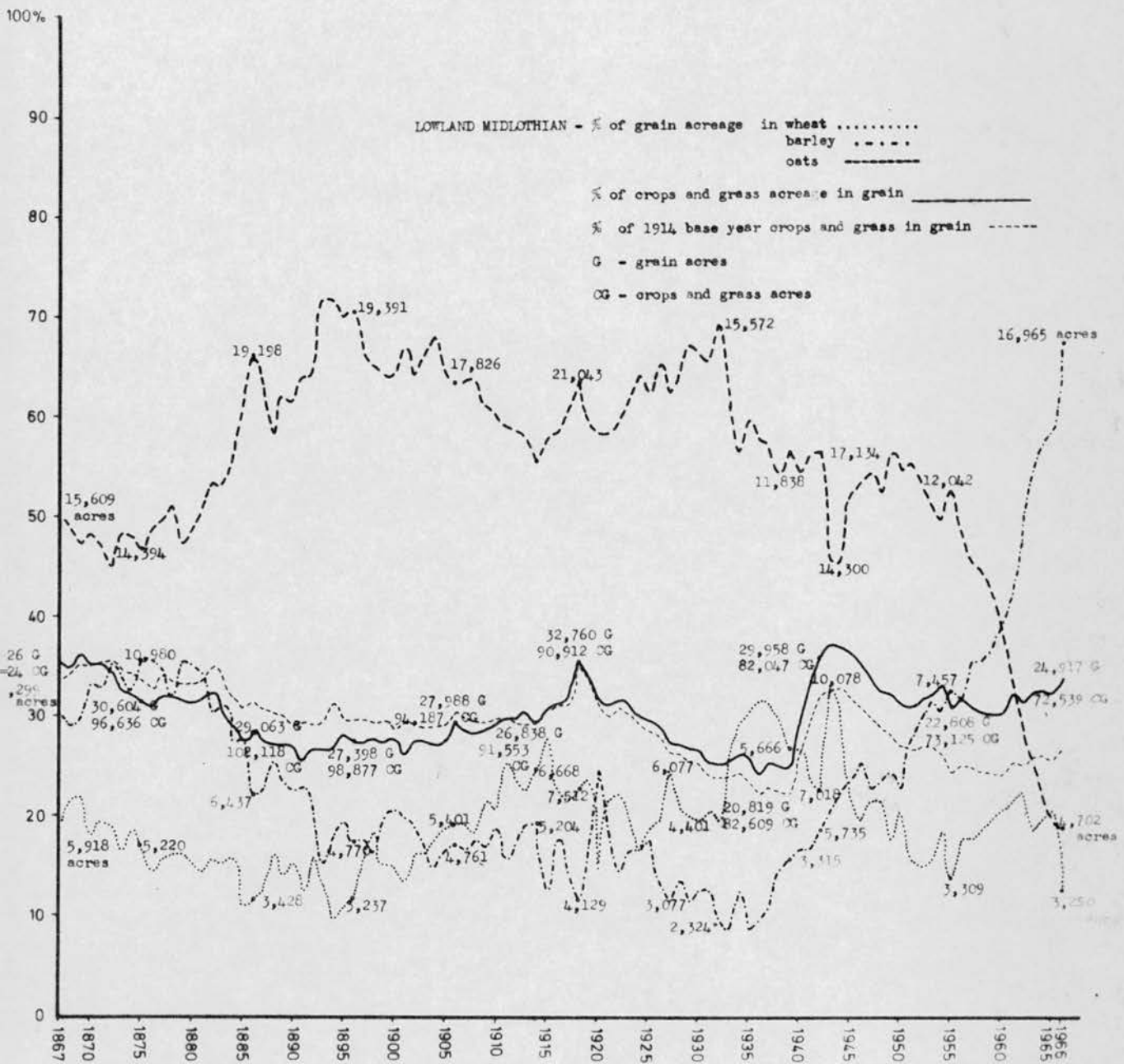


Figure 56

in the second half of the century and intensified after 1960 with barley taking the top position from oats. Wheat responded remarkably to the provisions of the Wheat Act 1932.

In upland Midlothian (Figure 57) the line graph pattern is representative of the Southern Uplands where barley occupies a comparatively important place in grain cropping and after 1960 approached the versatility of oats. New varieties have made this possible and permitted a response to market needs for high grade barley and other feed grain.¹

The Renfrew graph (Figure 58) is typical of southwestern and mainland Scotland where barley was of little importance until after 1955 and the second grain crop was wheat. Grain acreage decreased faster than crops and grass which actually increased for nearly 15 years before decreasing again up to 1914. From 1918 crops and grass decreased sharply despite the peak in 1942-3 and grain acreage decreased very rapidly after 1943. Some of the decrease in acreages was due to the urbanization of part of the county and this is made more apparent in equal area bar graphs to be examined later.

The graph for upland Sutherland (Figure 59) shows remarkably the effect of new land added to the crops and grass base by reclamation carried out under the sponsorship of the Duke of Sutherland, but some of the increase is explainable by

¹ The recently intensified approach to grain variety improvement is based on the work of early improvers such as Shirreff, Beaven and Biffen. See Smith, W. G., *The Improvement of Cereals*, Patrick Shirreff's Work, Trans. of the Highland and Agricultural Society of Scotland, pamphlet, 1910 pp. 1-16; Beaven, E. S., and Biffen, Sir R., *The Improvement of English Wheat*, Journal of Agricultural Science 2 (1907) January; and Beaven, E. S., *Barley Fifty Years of Observation and Experiment*, Duckworth, London, 1947.

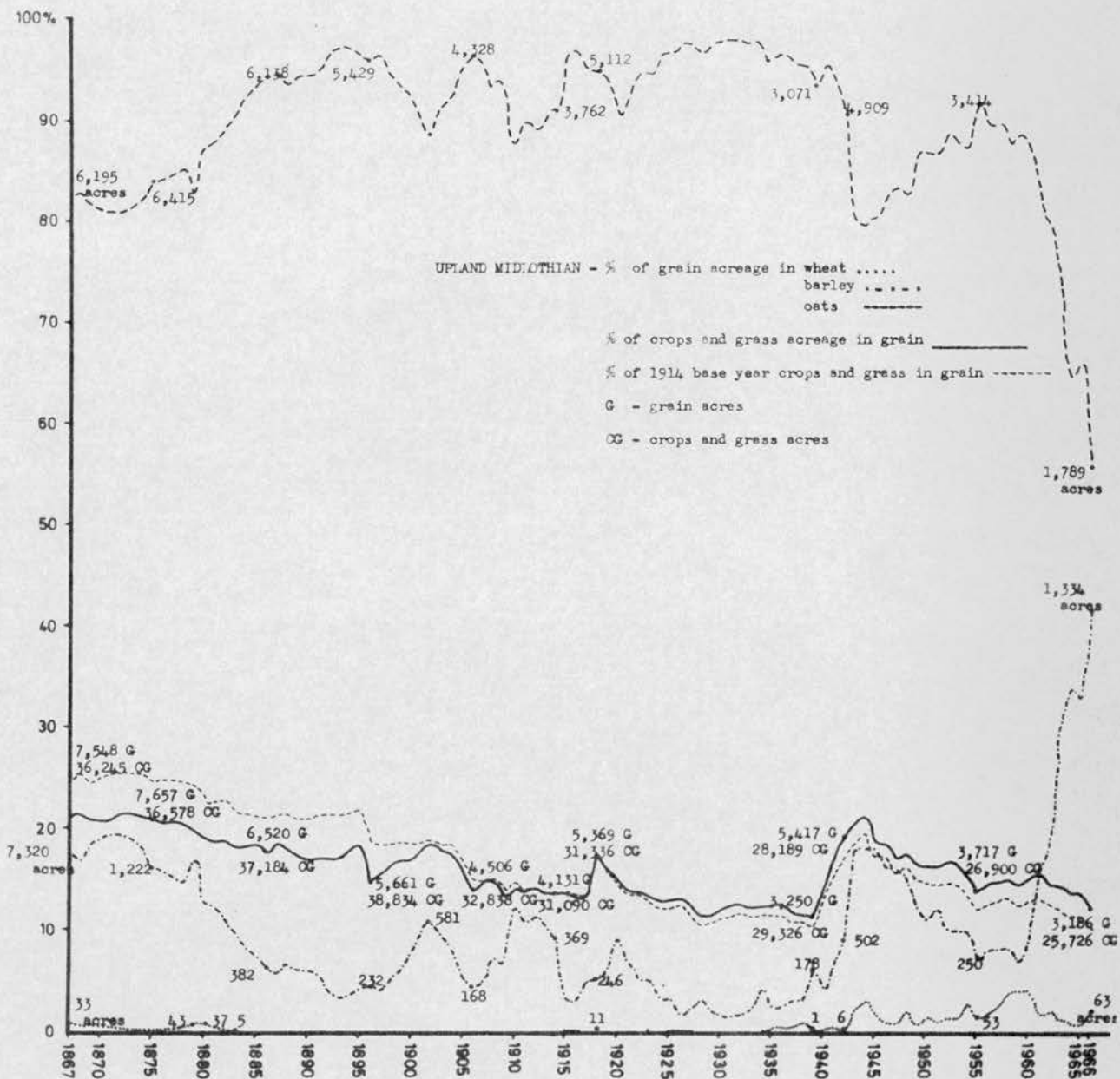


Figure 57

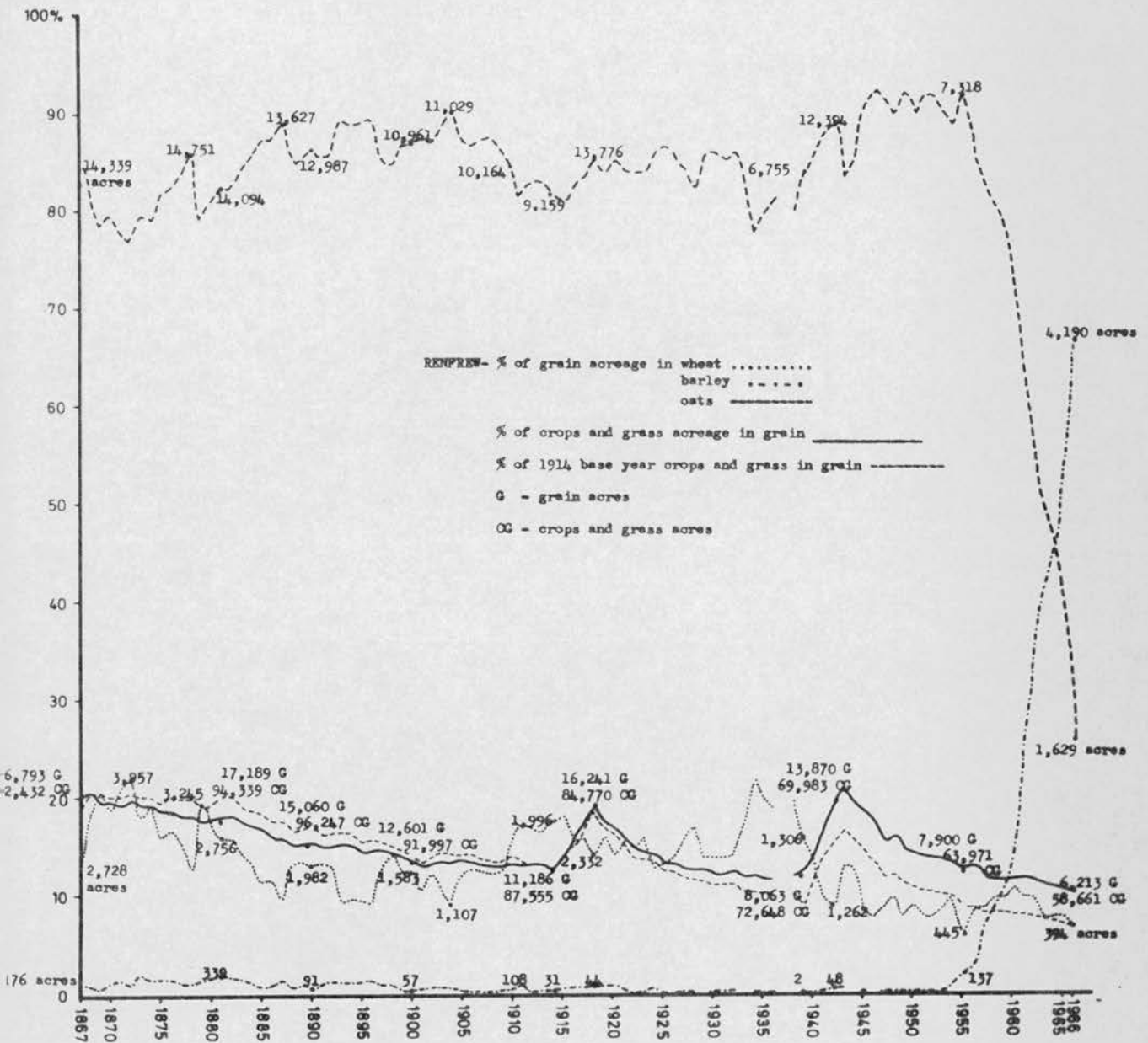


Figure 58

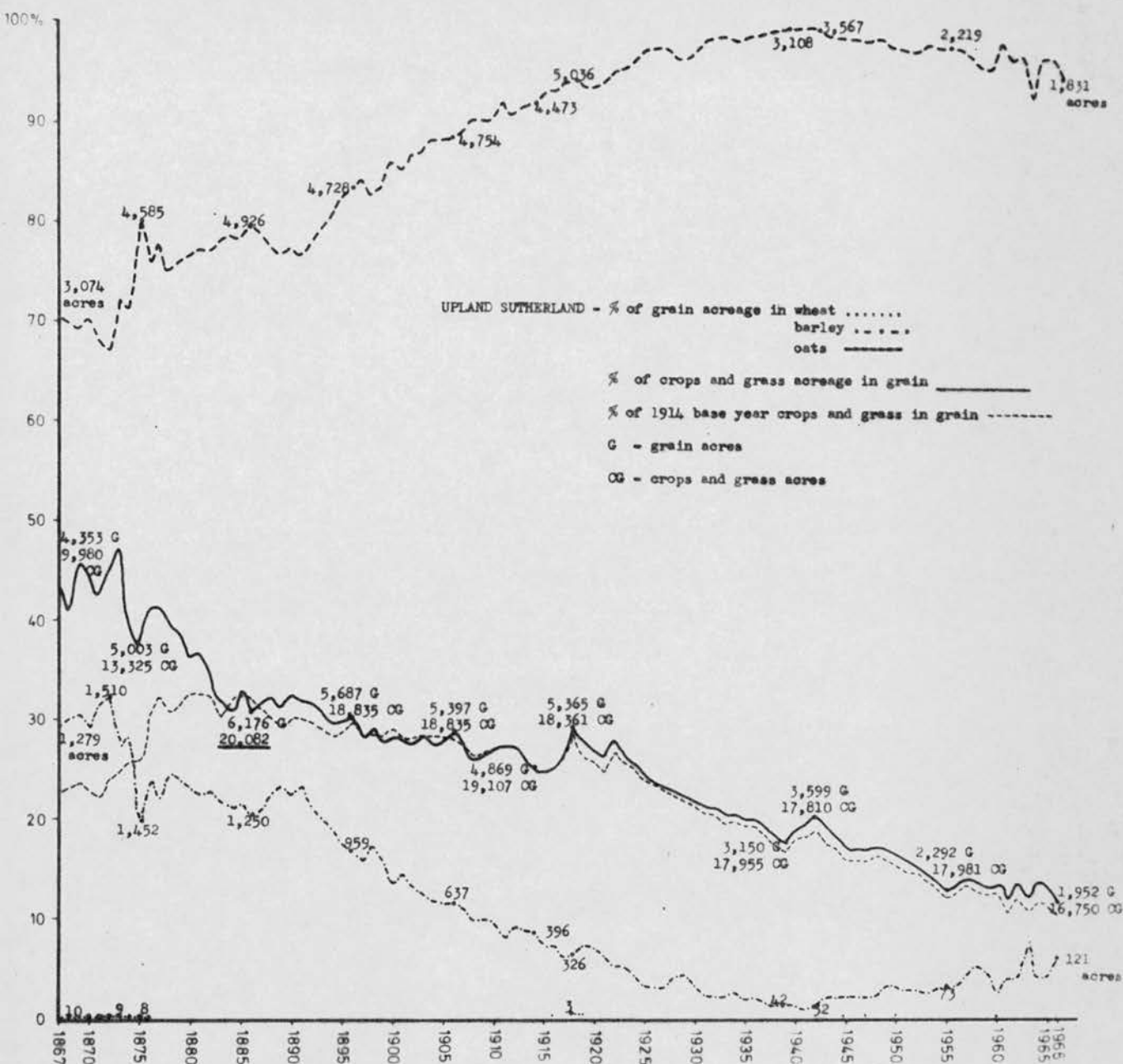


Figure 59

increased numbers of census returns as well.¹ In 1867 4,353 acres of grain were grown out of 9,980 acres of crops and grass and by 1885 grain had increased to 6,176 acres and crops and grass had more than doubled to 20,082 acres. From then to 1914 both categories declined but with grain declining more rapidly than crops and grass in certain years. After the peak of 1918 both categories declined and did not repeat the 1918 maximum in 1942. Wheat was never important in upland Sutherland and barley became less important to the end of the hundred years. The lowland Sutherland graph in Figure 60 has a different total grain pattern from 1867 to 1907 when grain increased somewhat more rapidly than crops and grass but both fell below the 1867 level by 1904. The coastal area was capable of growing some wheat on occasion and a few hundred acres of barley was increased to over 1,000 in 1964.

The line graph for Shetland (Figure 61) represents a grain region where acreage estimates are difficult to make and fields are often fragmented and patchy. A very sharp drop in crops and grass acreage in 1912 and 1913 bring the baseline and current graph line together in 1914. In 1867 10,602 acres of grain was reported out of 50,326 acres of crops and grass but after slight increases in grain acreage and considerable increases in crops and grass (possibly partly the result of a change in classification methods

¹Reclamation work around Lairg, Ardross and Badenlock in Sutherland added 7,400 acres to the arable total of Sutherland between 1853 and 1879. See page 48 in Macdonald, J., On the Agriculture of the County of Sutherland, Trans., of the Highland and Agricultural Society of Scotland, 4th Series, 12(1880). A similar program was reported by Macdonald, W., On the Agriculture of the County of Inverness, Trans., High. & Agric. Soc. 4th Ser. 4(1872) on pages 23-24.

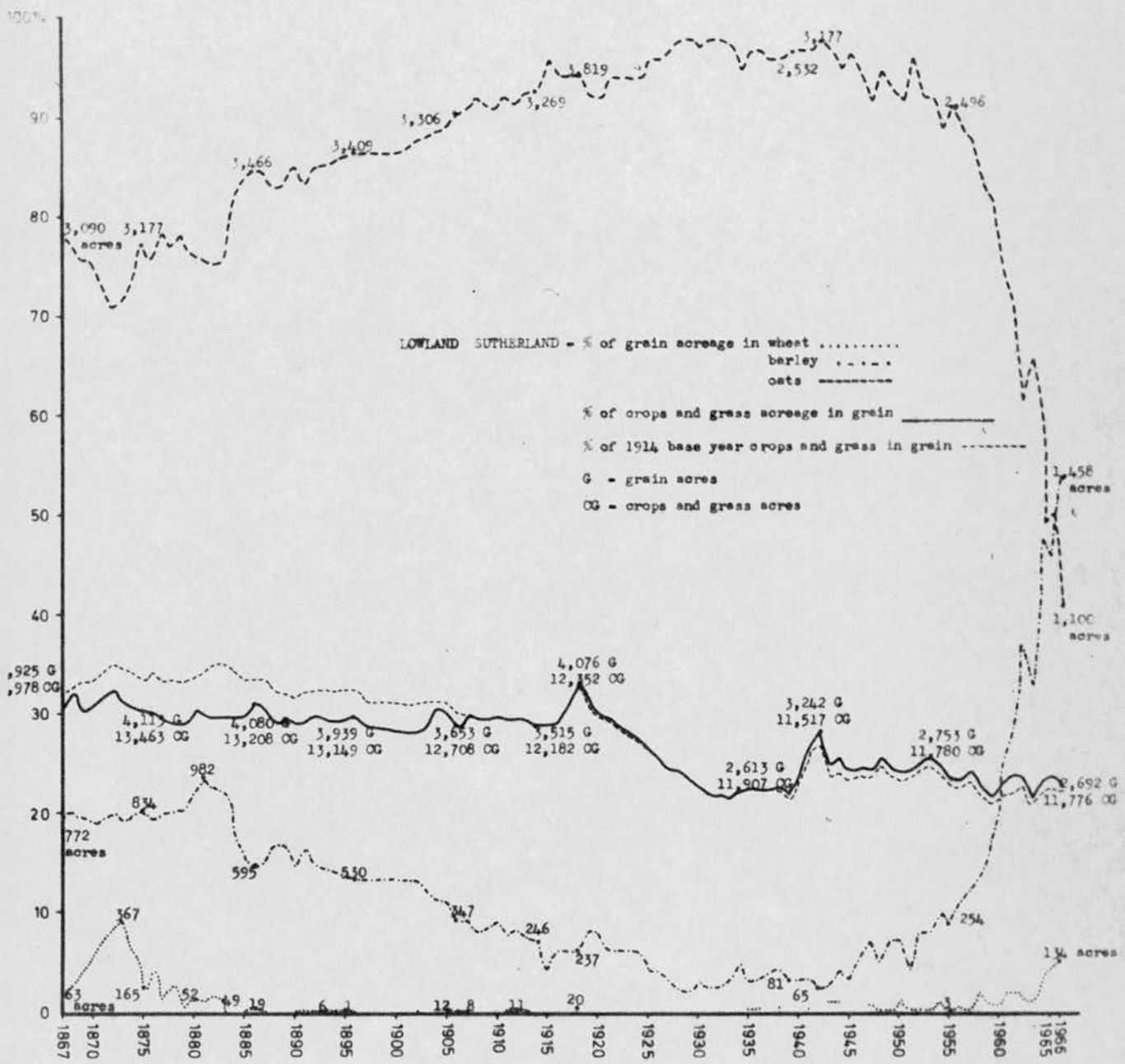


Figure 60

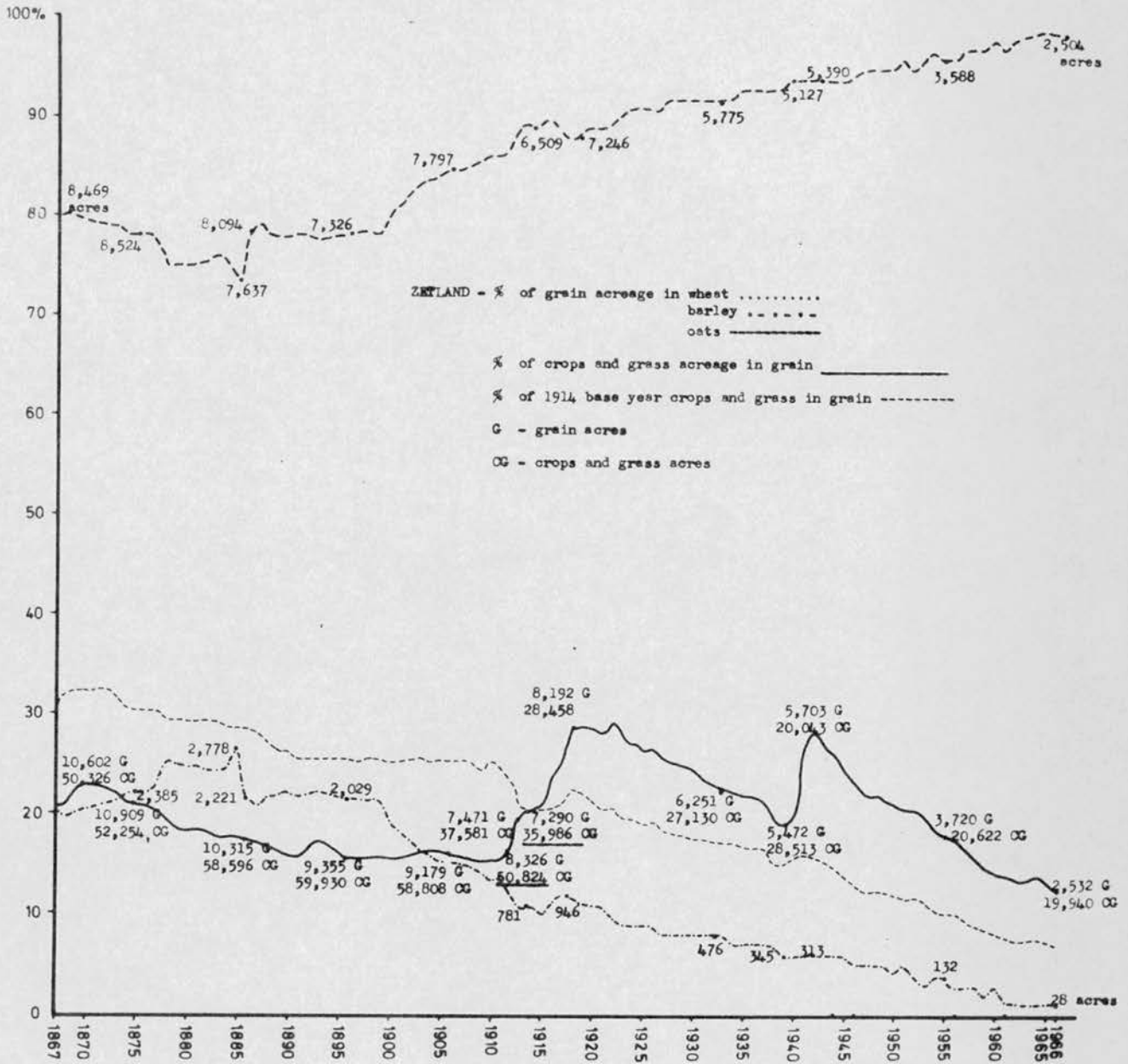


Figure 61

locally) both had declined to a low of 7,290 and 35,986 acres by 1914. The fall in the second half of the century was catastrophic in extent and clearly reflects the loss of arable land due to the aging of the farmers and loss of labour, especially since the end of the 1939-1945 war. The loss of over 8,000 acres of crops and grass from 1939-1942 was made up largely in the remote islands, with 2,250 acres accounted for in Northmavine, 1,635 in Unst, 833 in Fetlar and 640 in Delting. After 1942 grain acreage fell much more rapidly while the maintenance of improved grass reflects an increased dominance of the livestock raising industry.

The foregoing line graph examples are representative of the set which may be found in Appendix C. The patterns fit in well with the historical and political factors listed earlier. The maintenance of a fairly high level of grain production went on to 1875 when the long slow decline generally began and continued to the low level of 1914. The heavy demands on the economy induced the rise from 1914 to 1918 and to some extent the effect of the Corn Production Act 1917 is shown until 1920. Another long slow decline to the deep low of 1939 is evident throughout, though it was generally steeper in upland areas than in the more arable lowlands. The Wheat Act 1932 changed the pattern in lowland Midlothian and Renfrew after 1932 and this pattern is a sample of similar changes in lowland Angus and Perth, West and East Lothian, lowland Berwick and Roxburgh and other areas where wheat could be grown.

Total grain acreage was very often at its lowest in 1939 but the onset of war in Europe led to a spectacular recovery although the second wartime peak did not always reach the heights of the 1918 one.¹ After 1943 an irregular decline continued generally to 1960 in the more arable areas. It was replaced by a flattening of the graph curve and a slight increase during the intense specialization and rise of barley after 1960. In the highland-uplands the period 1943-1966 saw both grain and crops and grass acreages fall. This may reflect the return of the marginal land to more permanent pasture, the loss of labour and population from the highland-uplands generally, and the effect of cheaper grain imports on local markets. The graphs indicate quite clearly that the attempt to increase grain crop yields on land suited to grain cropping is the most efficient and lasting method.² The expansion of grain growing outside of these areas is temporary at best and very expensive if it is to be maintained for any length of time. The expenditure of modest sums on improving land which has been in cultivation for a long period reaps considerably greater returns than the expenditure of very large amounts to bring marginal land into cultivation and to maintain it. The war induced expansion of grain cropping on marginal land has had a most ephemeral influence on overall output.

1. Some of the difficulties in gearing to a wartime economy are outlined on pages 245-47 by Symon, J., *Scottish Farming*, Oliver and Boyd, Edinburgh 1959.

2. See page 47 in Stamp, L.D., *Wartime Changes in British Agriculture*, *Geographical Journal* 109(1-3)1947 pp.39-57, where he stated that during the war a 10 per cent increase in production from the land already in use would yield as much as the ploughing of additional marginal land. Regularly ploughed land is much more flexible in use than land a longtime in grass.

Acreage Number Pattern Maps 1867-1966

The number pattern maps were developed in response to the need to see what was happening in Scotland at all places at once in any one year. The grain acreage number patterns give details of wheat growing in Caithness and Orkney on a scale not exceeding a trace (less than one half of one per cent of the total area in grain) and in Perth, Angus, Fife and the rest of the Firth of Forth area where wheat is a very significant crop. A continuous set of reference maps giving multi-regional coverage by single years and covering a number of divisions of the cropping pattern was essential to fill in the gaps in the other representational material. Only after they evolved was a precedent for the number pattern method found indirectly in sources reported from Sweden.¹ Although the application was not the same and the reference material was in a less processed state, the idea of multi-dimensional representation, retrievability of data and areal comparability was implicit.

The ratio of grain to crops and grass acreage was often over 20 per cent in the highland-uplands in 1867 (Figure 17 on page 81). In that year the grain acreage number pattern map shows upland Sutherland, Ross and Cromarty, Inverness, Moray, Banff, Aberdeen, Angus and Perth with percentages ranging from 21 to 44. In 1918 the range was 23 to 34 and in 1966 from 11 to 22 in the upland sections of those counties. At the same time the pattern in the somewhat more exclusively highland-upland counties of Argyll, Bute and Peebles dropped less spectacularly from grain acreages of 18, 25, and 24

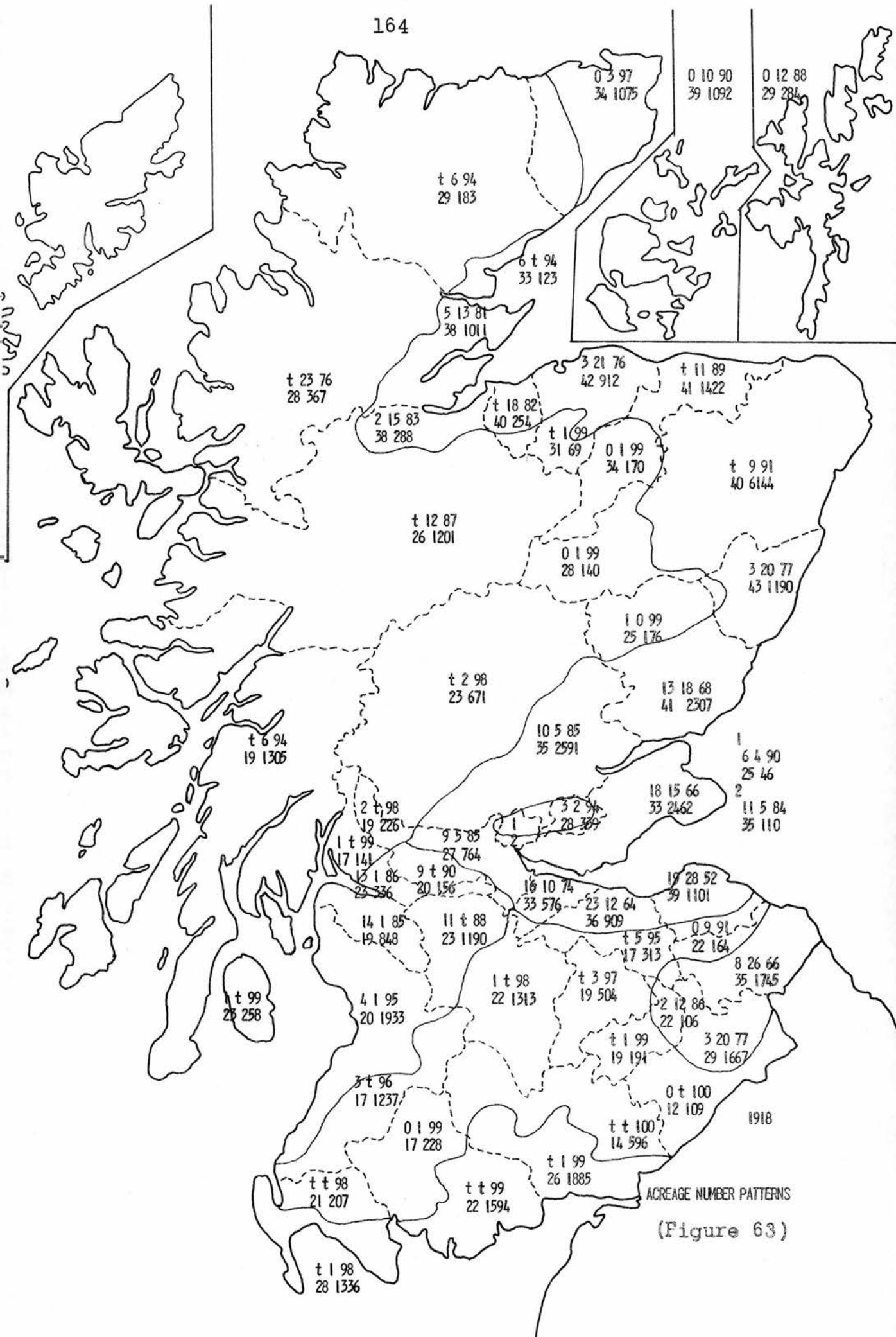
¹ See Hedbom, O., on F. Petrini's work in 1962, op cit page 84.

to 10, 11 and 14 per cent of crops and grass in 1966.

A host of changes to do with depopulation in rural areas, loss of farm labour, the rise of specialized livestock grazing industry, the return of marginal land to grazing and others, took place in the hundred years. The acreage number pattern map for 1914 (Figure 62) gives ratios and acreages in one of the low trough years, which came at the end of a long decline from about 1875. The importation of cheaper grain from abroad brought considerable hardship to farms in the more marginal areas where there were no good cash crops to be grown as an alternative to grain. Compared to the 1914 map the 1918 one offers a year of peak acreage patterns (Figure 63). Coming the year after the Corn Production act 1917, the 1918 peak is most interesting for the increases in oats and wheat acreages. Since no incentives were offered for barley the acreages devoted to it declined. In the traditionally better barley growing areas, barley was down 15 per cent in 1918 from the 1914 position in East Lothian, 13 per cent in lowland Angus, 12 per cent in lowland Inverness, lowland Moray, Fife and lowland Berwick, 11 per cent in the lowland parts of Ross and Cromarty and Roxburgh, 10 per cent in Kincardine, 7 per cent in lowland parts of Perth and Midlothian, 5 per cent in West Lothian and 2 per cent in lowland Aberdeen. The 2 per cent drop in lowland Aberdeen is as significant as the change in lowland Angus in real acreage terms. This fact emphasizes the problem of areal comparability where the base units (assembled from the parish records) differ markedly in size.

ACREAGE NUMBER PATTERNS

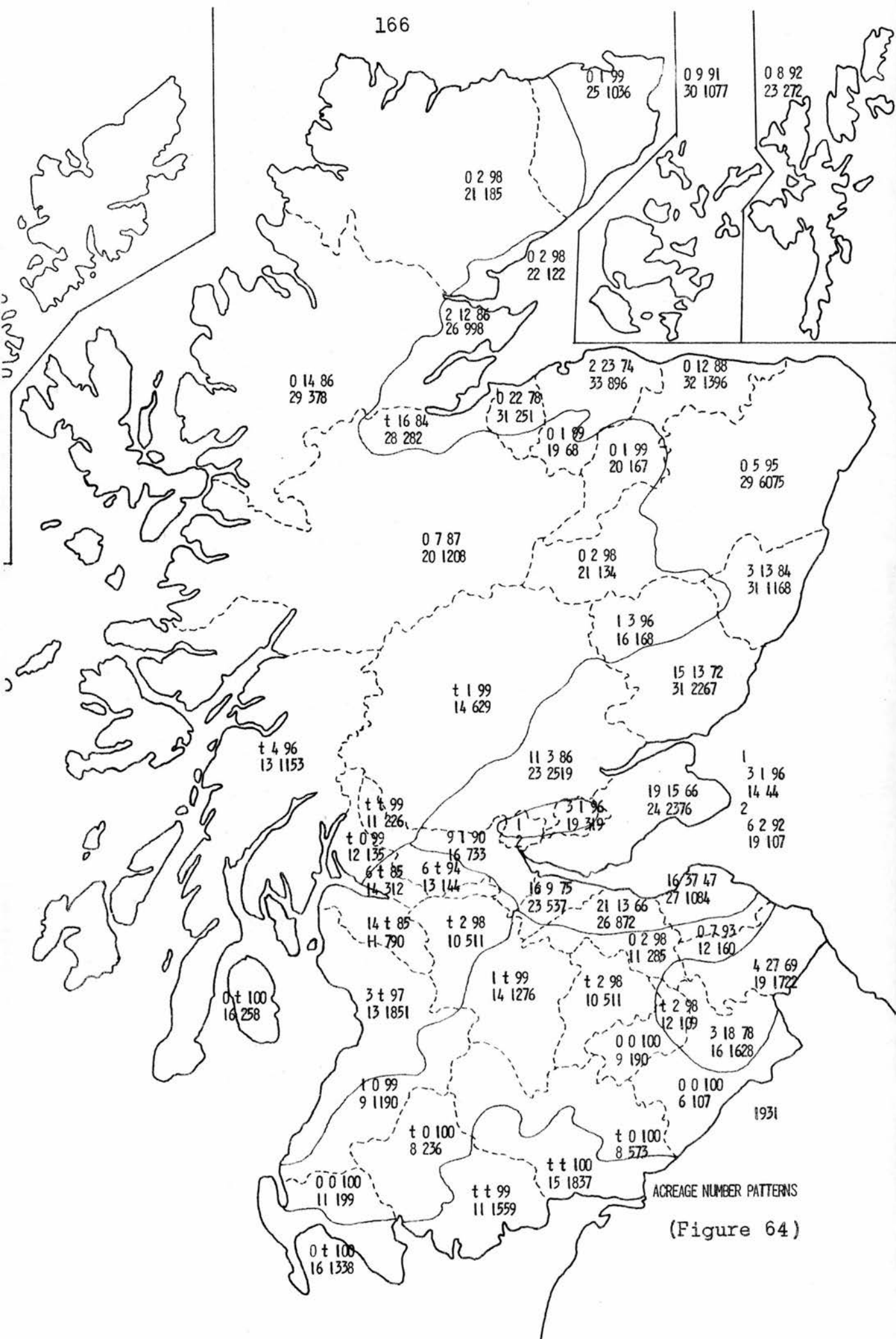
(Figure 62)



ACREAGE NUMBER PATTERNS
(Figure 63)

The 1931 acreage number pattern map (Figure 64) gives an example of a break point in the long years of decline from 1918 to 1939. In many years where wheat had enjoyed a brief period of favour during the later years of the 1914-1918 war, it does not appear in the percentage ratios or is present as a trace only. The 1934 acreage number pattern map (Figure 65) shows the remarkable recovery of wheat acreage as a result of guaranteed subsidies offered under the terms of the Wheat Act 1932. Since the effects of the Act were only noticeable in 1933 in counties where good land made possible rapid changes from one crop to another to meet market demands, the main effect in Scotland was delayed to 1934. The rise in the importance of spring sown wheat dated from about this time and became very important for about a decade.

The greatest changes in percentage of acres devoted to wheat growing between 1931 and 1934 took place in East Lothian, West Lothian, the Forth area of lowland Stirling, lowland Perth, Fife, lowland Angus and lowland Berwick where there was an increase of more than 10 per cent. Other swings of between 5 and 9 per cent took place in lowland Midlothian, Kincardine, lowland parts of Moray and Ross and Cromarty, Renfrew and lowland Lanark. Although not so large the changes in grain ratio patterns in the highland-uplands fringe and in the southwest are exceptionally significant as they represent some of the first evidence of an attempt to break the old oats dominant cropping pattern since the general decline which began about 1875. However, the relief offered by protective measures was withdrawn after 1937 and

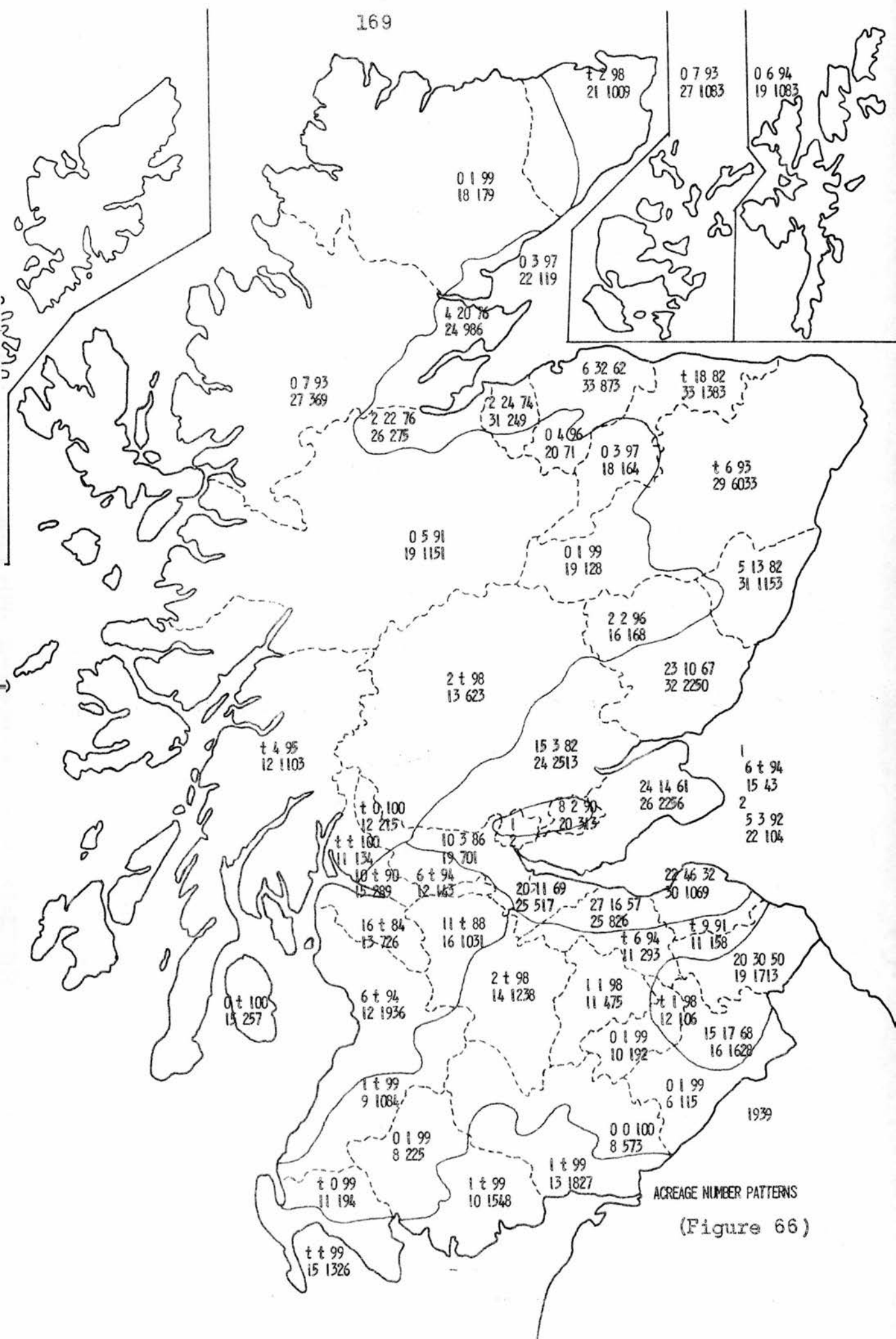


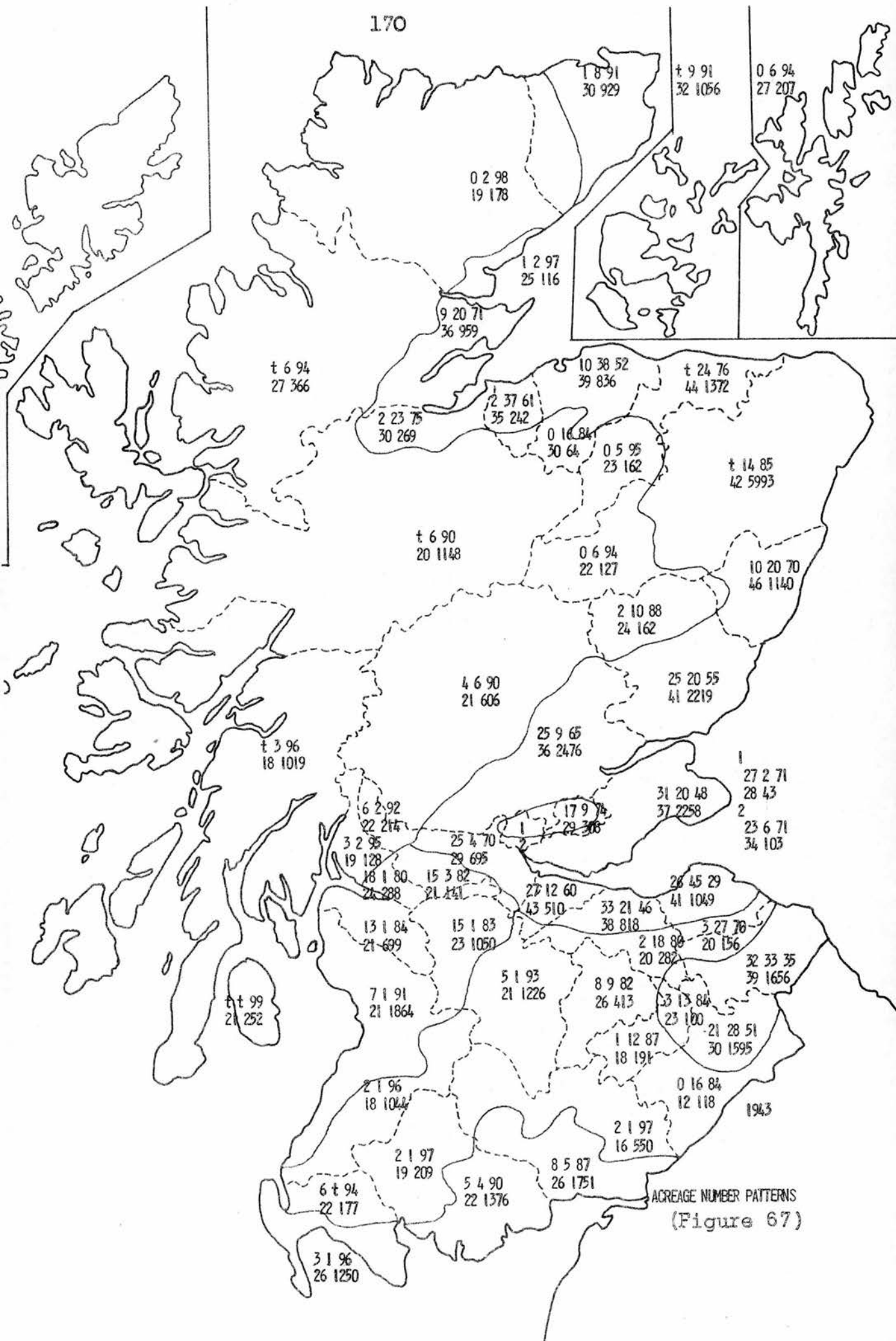


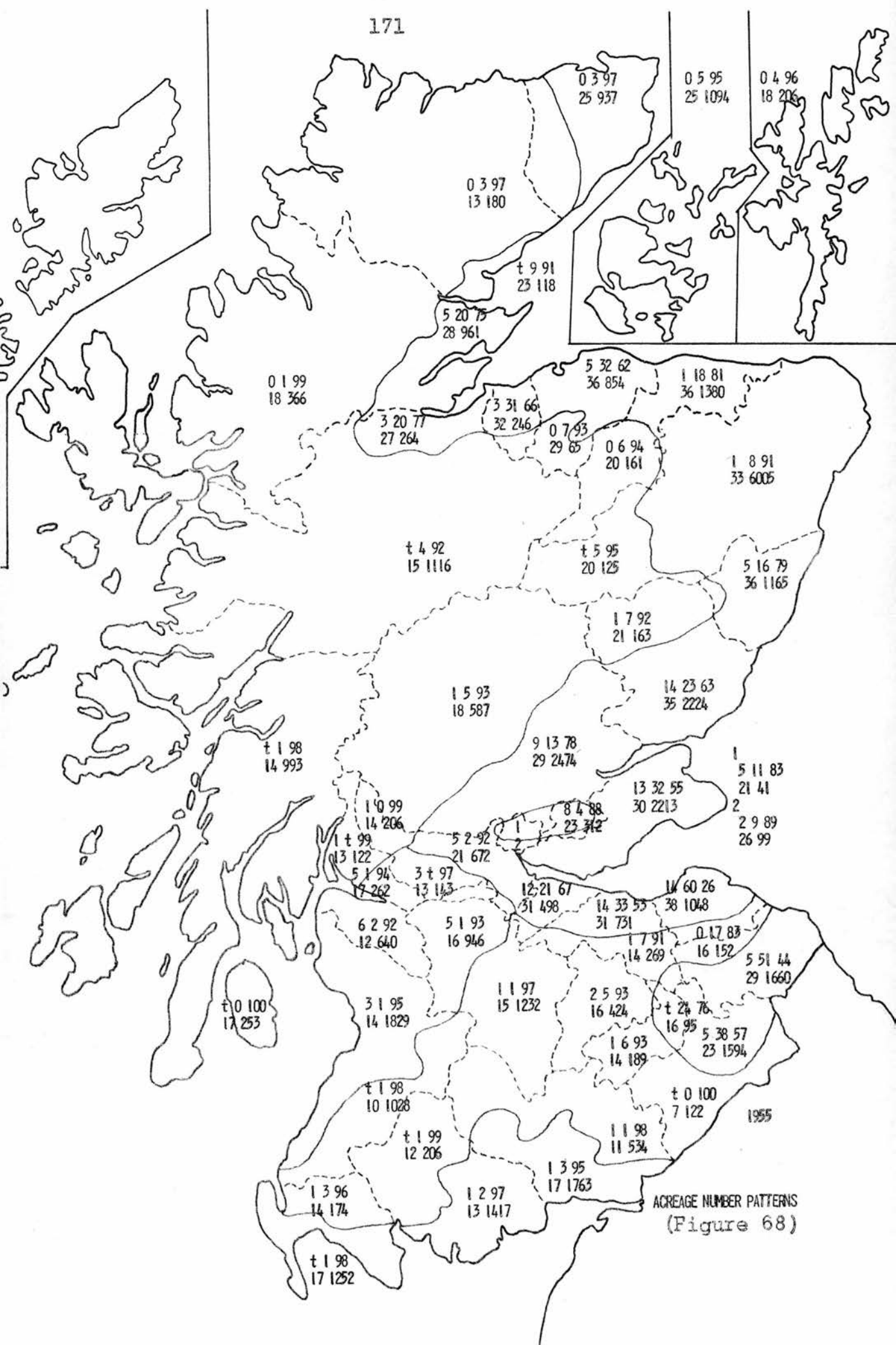
wheat acreages dropped sharply.

The deepest low in grain acreages was experienced in 1939 (Figure 66) and the Grassland Ploughing Subsidy of £2 per acre was introduced to encourage the ploughing of land which had been 7 years or more in grass. The aid came at a crucial moment and the onset of war later in the year put heavy demands on agricultural land. The patterns in the map for 1943 (Figure 67) give a measure of the changes wrought by unusual economic demands on the grain farming economy. One of the most interesting changes in the 1939-1943 period was in the percentage of crops and grass devoted to grain. The part occupied by grain increased from 30-41 per cent in East Lothian, 25-38 per cent in Midlothian, 25-43 per cent in West Lothian, 19-39 per cent in lowland Berwick and 16-30 per cent in lowland Roxburgh. North of the Forth, grain increased from 26-37 per cent of crops and grass in Fife, 24-36 per cent in lowland Perth, 32-41 per cent in lowland Angus, 31-46 per cent in Kincardine, 29-42 per cent in lowland Aberdeen and 33-44 per cent in lowland Banff. Caithness managed an increase in grain from 21-30 per cent and Shetland from 19-27 per cent of crops and grass acreage. From a deep low in 1939 an increase was made from 10-22 per cent in lowland Kirkcudbright, 13-26 per cent in lowland Dumfries and 12-21 per cent in lowland Ayr.

The acreage number patterns for 1955 (Figure 68) show the situation after the sharp declines from 1943 before the switch in grain crop emphasis to barley.

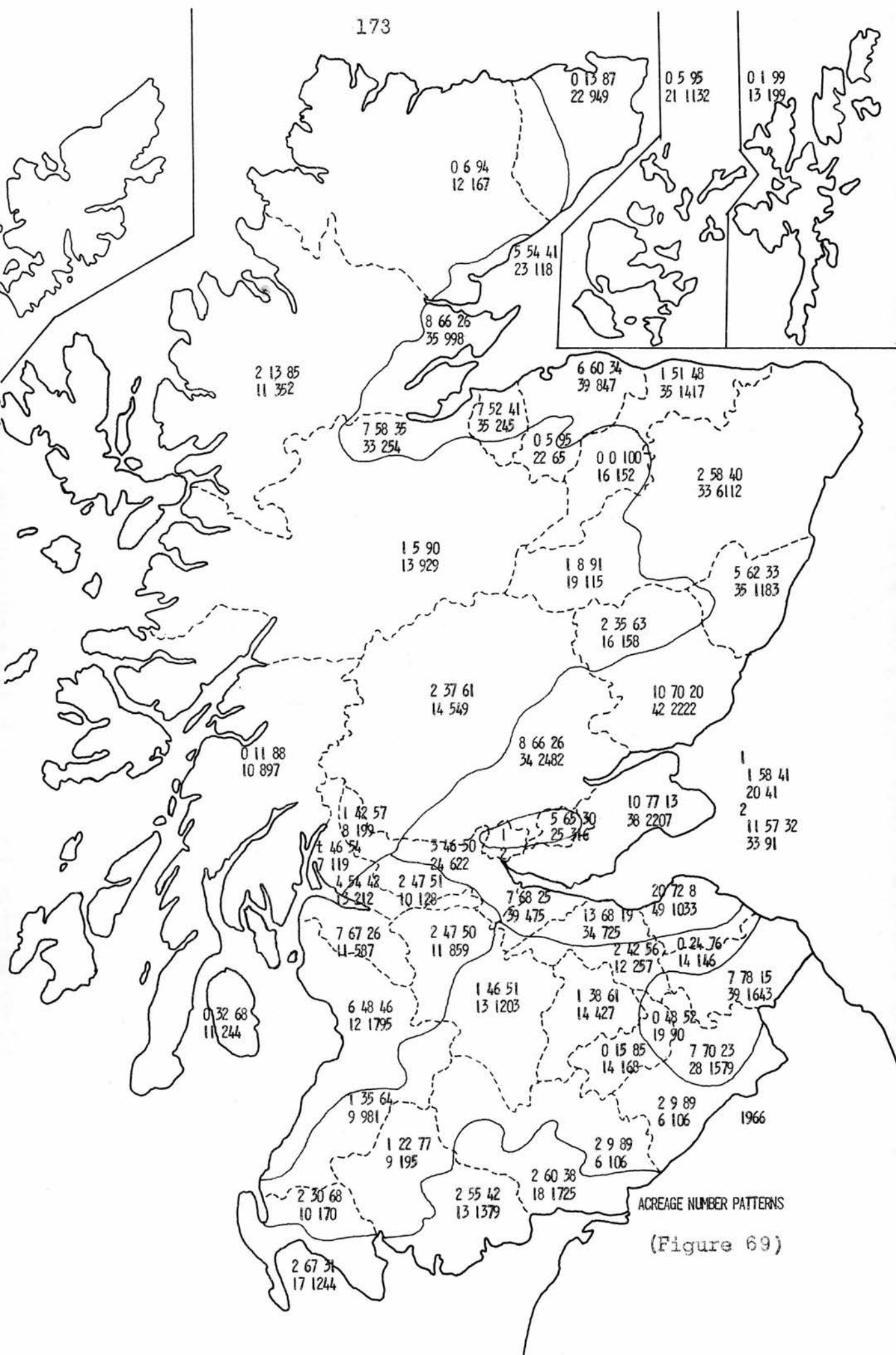






The 1966 map (Figure 69) gives some measure of the changes. Old ratio patterns with small amounts of wheat and barley and percentages in oats exceeding 75 per cent have been drastically altered and the recognizable regional grain patterns which had endured for the greater part of one hundred years are wiped out. The remarkable switch to barley in a new area for it from 1955-1966 is shown by the change from 1-48 per cent of all grain acreage devoted to barley in lowland Ayr, 1-67 per cent in lowland Wigtown, 2-55 per cent in lowland Kirkcudbright and 3-60 per cent in lowland Dumfries. Although these changes were on a fairly small grain cropping base and do not compare on an acreage basis to the heavy swing from 8-58 per cent in lowland Aberdeen, they are regionally highly significant. Even the traditional barley growing areas show a remarkable concentration in barley growing between 1955 and 1966 with East Lothian showing an increase in acreage from 60-72 per cent, lowland Berwick 51-78 per cent, lowland Roxburgh 38-70 per cent, lowland Midlothian 33-68 per cent, West Lothian 21-68 per cent and Fife 32-77 per cent.

Other remarkable changes were in lowland Forth area Stirling with 2-46 per cent, lowland Perth 13-66 per cent, lowland Angus 23-70 per cent, Kincardine 16-62 per cent and lowland Banff 18-51 per cent. Even the Moray Firth counties showed a heavy concentration in barley growing in 1966 in comparison to 1955 with lowland Moray increasing from 32-60 per cent, Nairn 32-60 per cent, lowland Inverness 20-58 per cent and lowland east coastal Ross and Cromarty 20-66 per cent. The comparison of these key maps which reflect situations



clearly shown by the line graphs, offers fascinating results. It is not the intention to continue a long discussion but to leave the maps to account for the story themselves.

In one hundred years of agricultural statistics, the acreage number pattern maps offer a sequence of reference material, recorded by divided counties and counties in 54 units. The changing emphasis on wheat, barley and oats in areas susceptible to alternation is also clearly evident as well as the dominance of oats growing in more marginal grain cropping areas. The gradual spread of barley as the dominant crop westwards, southwards and northwards from the traditional barley growing parishes of East Lothian and Fife is also effectively portrayed. The provision of the actual crops and grass base offers a measure of size and indication of areal comparability. Together with the line graphs 1867-1966, the acreage number patterns present a year by year chronicle of events. All of the remainder of the grain representational material in the form of maps, diagrams and graphs, deals with the peak, trough and some of the more average years suggested by the year to year reference material. The search for a more finished form of multi-dimensional representation giving multi-component coverage has not revealed a method with as good retrievability of the statistics as the acreage number pattern maps. They offer a valuable source of reference material when comparing the changes over any period of years.

Distribution Patterns in Density Shaded Maps

a. Percentage parish-based maps

There are a set of eight maps presented on two sheets Figures 70 and 71, beginning in 1896 and continuing on by key years to 1966. The year 1896 was chosen as representative of a year in the long decline from 1875 to 1914, and the crops and grass category for individual parishes was not available to use as a reference base for much earlier than that date.

Over the hundred years, the major change evident was a shrinking of the percentage of grain in the highland-upland areas with brief revivals in 1918 and 1942. In the more arable lowlands, large areas had percentages of grain as high as 31-45 per cent in 1896, 1914 and 1918 but these areas were considerably reduced in 1931 and 1939. The large-scale turn to grain during the 1939-1945 war is evident in 1942 but this extreme swing was not maintained and the 1956 map shows a picture very similar to 1896 or 1914. A larger scale dependence on grain as a cash crop after 1956 is evident in the final map of the series in 1966. A great number of parishes in Angus, south Perth, Fife, West Lothian, and East Lothian show percentages of crops and grass in grain exceeding 45 per cent. In fact several parishes in eastern Angus reported over 50 per cent of the available crops and grassland in grain, as did several in the north of Fife and in southeastern Fife. In East Lothian; Dunbar, Whitekirk, North Berwick, Dirleton, Athelstaneford, Prestonkirk, and Ormiston reported over 55 per cent as did Cramond,

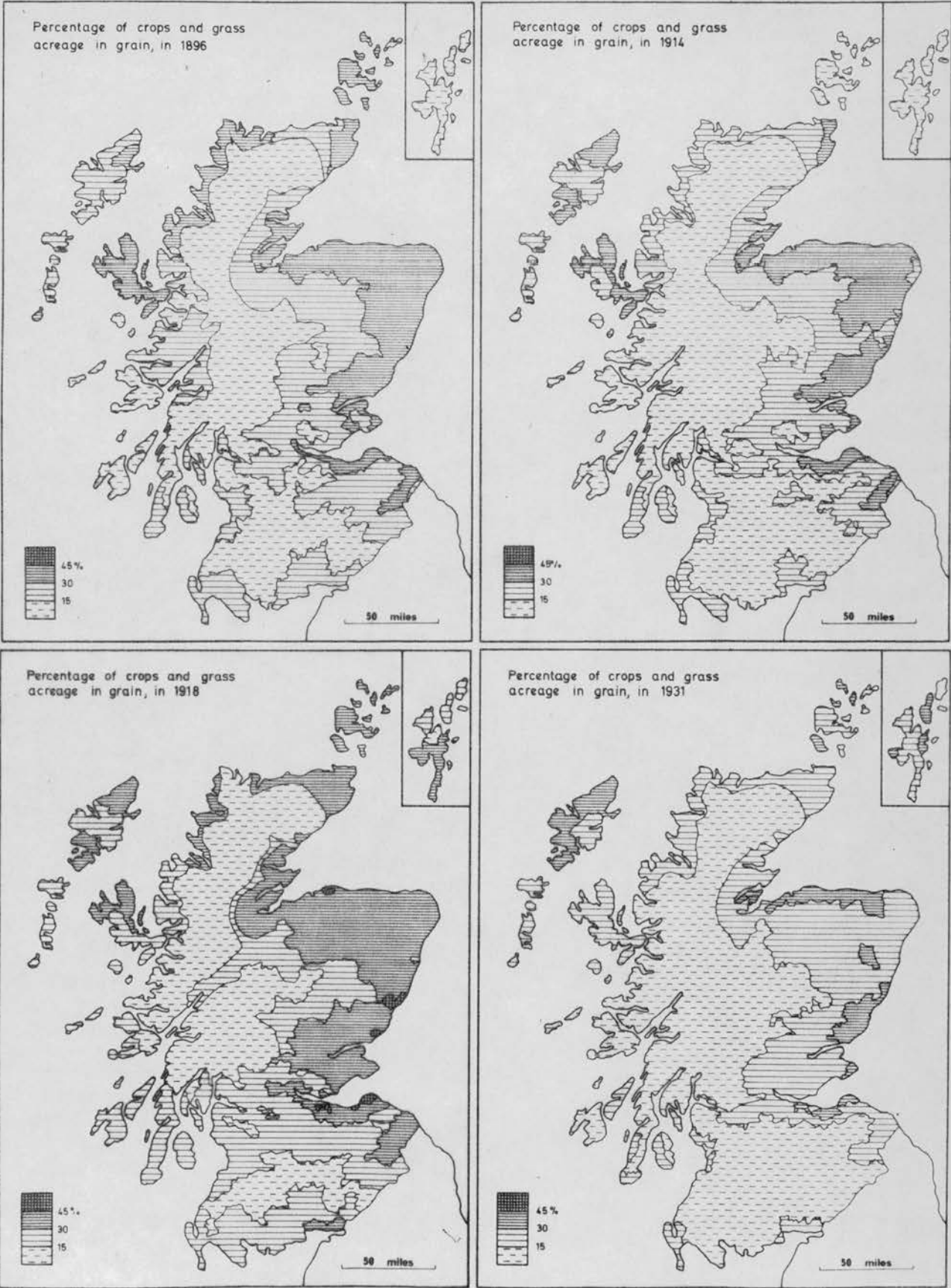


Figure 70

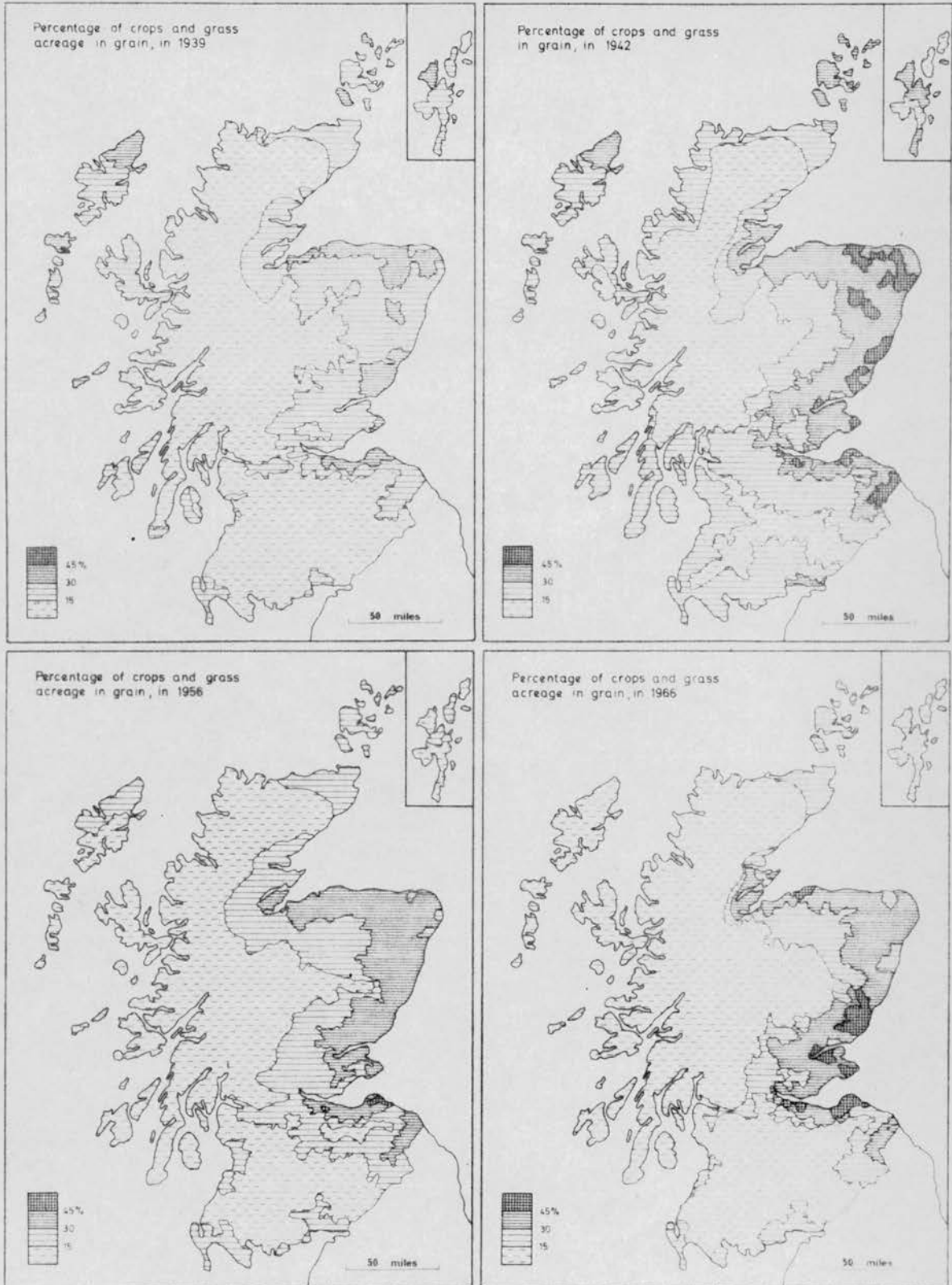


Figure 71

Edinburgh, Newbattle, and Kirkliston in Midlothian, and Kirkliston, and Bo'ness and Carriden in West Lothian. This recent swing to grain and away from alternative more labour-intensive crops is part of the general pattern in Scotland in the last years of the century under examination.

b. Actual Acreage parish based maps

The total acreage of grain map of 1966 (Figure 72) offers somewhat different information since it reveals the largest grain growing areas in eastern Aberdeen and in the Merse of Berwick and neighbouring lowland Roxburgh. This map is offered as a comparison to the percentage map for the same year. Neither is ideal as the real acreage map favours the large parishes with large acreages of grain to report and the percentage map favours the small highly-arable parishes with comparatively small acreages of crops and grass but larger amounts of it in grain. Together they show something of the manipulations which can be made to statistics even though both use scales which are quite comparable (as an examination of the overall outline patterns reveals). The total crops and grass acreage map for 1966 shows clearly the base on which crops may be grown and the rough grazing acreage within the farm unit map offers emphasis of the vast areas of hill grazing land. In the southwest, the large grazing upland base of the counties is separated from the small arable lowland parts. This map helps to explain the continued emphasis on livestock farming throughout that area even though the newer varieties of grain are adaptable to the moist climate.

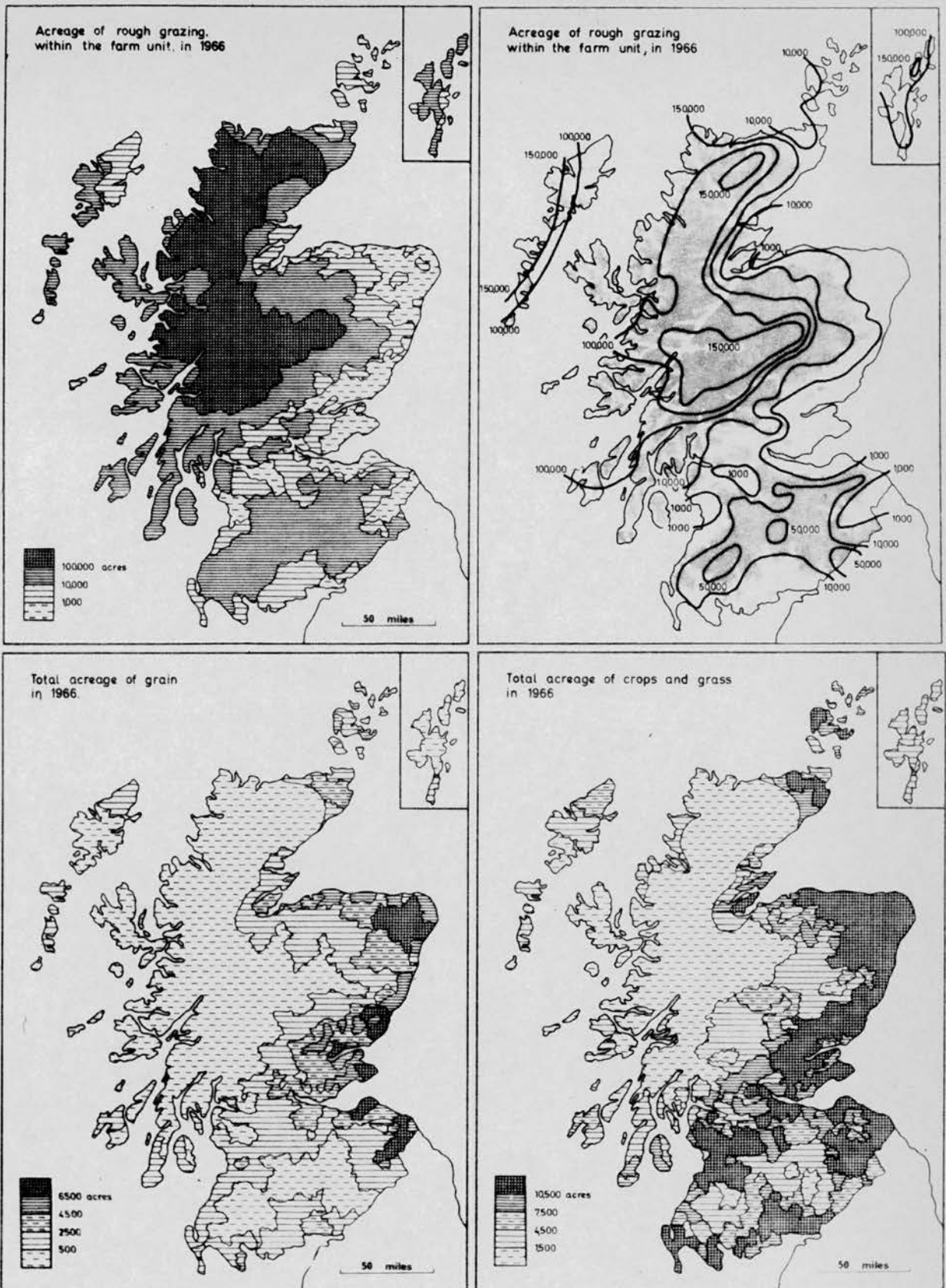


Figure 72

Overall Percentage Change Maps

The four grain percentage change maps 1896-1914, 1914-1918, 1939-1942 and 1946-1966 (Figure 73) are useful in revealing overall periods of negative and positive change. For example, the 1896-1914 change map shows a period of largely negative change but without exceeding 15 per cent except for one parish in western Skye. In 1914-1918 the maps shows an overall swing to the positive side generally, on the higher end of the 3-15 per cent range in the better grain growing areas and in the lower area for less favourable areas. A map is not presented showing the decline from 1921-1939 since it is similar to the 1896-1914 picture. The 1939-1942 period shows a positive change and the scale chosen begins to reveal what it is intended to do, that certain parishes in eastern Ross and Cromarty, Aberdeen, Angus, Perth, Fife, West Lothian, Midlothian, Berwick and Roxburgh are capable of heavy outputs of grain. In addition newer varieties have made possible the elevation of parishes in Dumfries and Wigtown into the higher category as well. The 1946-1966 map shows the mixed picture expected after the extreme effort of 1939-1942, with large areas with climates and situations less suited to grain growing swinging to the negative side of the scale. The key areas remained as before, except in the southwest and a positive pattern reappeared in Moray and Nairn.

This type of map is useful only where a number are shown together but it is not the most expressive method of revealing the situation. To show both negative and positive

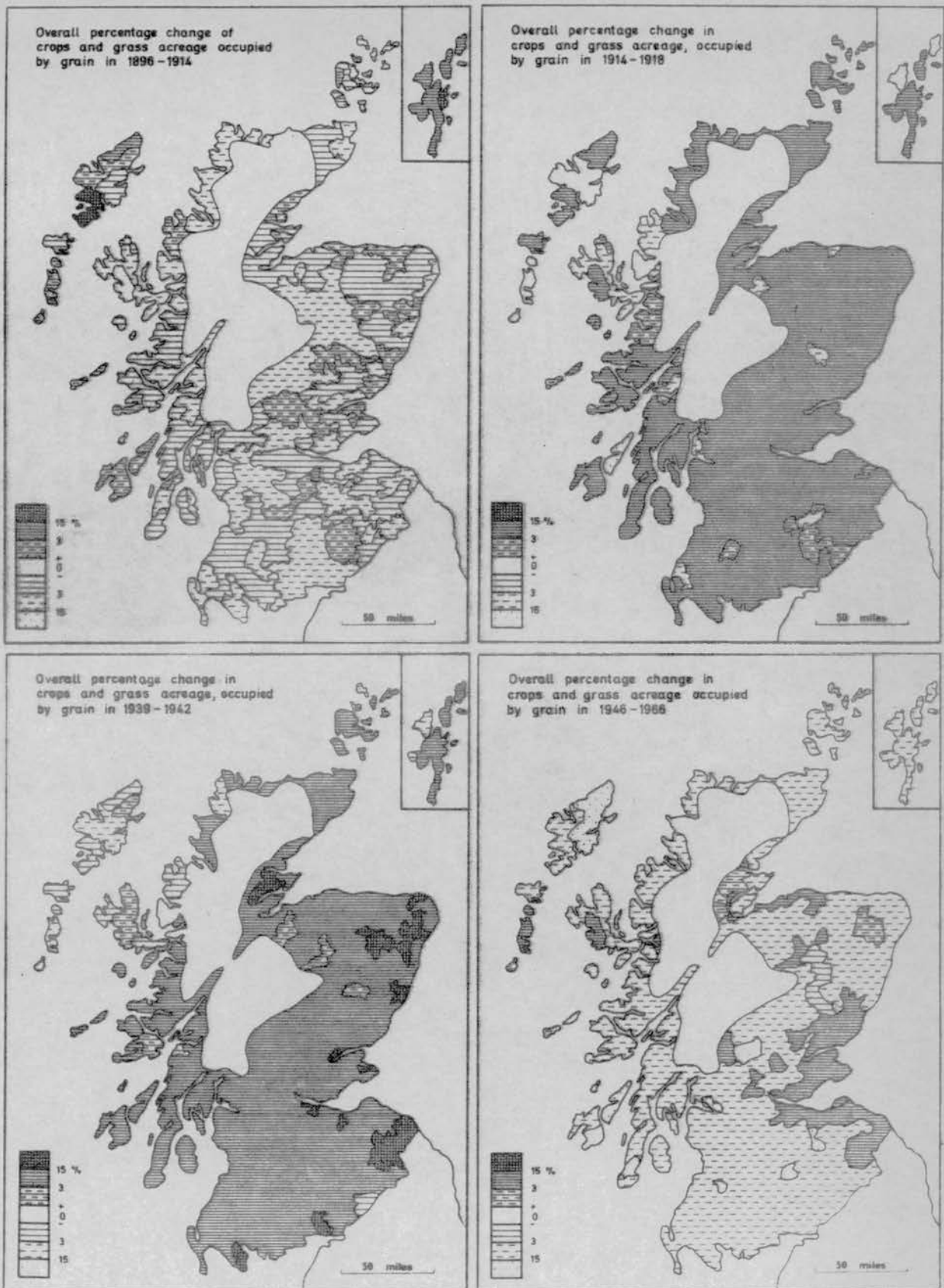


Figure 73

swings on one map, six or more scale divisions are required. Too many divisions leads to excessive fragmentation of the pattern. As with the static percentage maps, these maps favour the small intensively arable parishes and the larger ones with more grass and less crops drop down in the scale. In the 1946-1966 map the 0.1 to 2 per cent positive change in central eastern Aberdeen stands for a large real acreage increase comparable to change in the Lothians, Fife or nearby Angus, under the 3-15 per cent positive change listing on the scale.

Overall Acreage Change Maps

As a contrast to the percentage change maps which tend to favour small intensively arable parishes, the three acreage change maps (Figure 74) offer a different viewpoint favouring the large parishes. A different sequence of years is used to illustrate variations on the situation already revealed in the line graphs. The 1866-1966 overall acreage change map can be compared with the 1956-1966 map. The overall comparison reveals that the major acreage change in the better arable eastern lowlands was the increase in grain acreage in northeastern Aberdeen. This increase did not take place solely in the 1956-1966 period but must have been gradual over the longer period. In contrast, increases in eastern coastal Ross and Cromarty took place in the last ten years of the century as did those in the fertile Carse of Gowrie of Perth. In other areas the three maps show a pattern of overall negative change. The optimism of the 1866-1875 period and earlier, is not shown in the 1956-1966

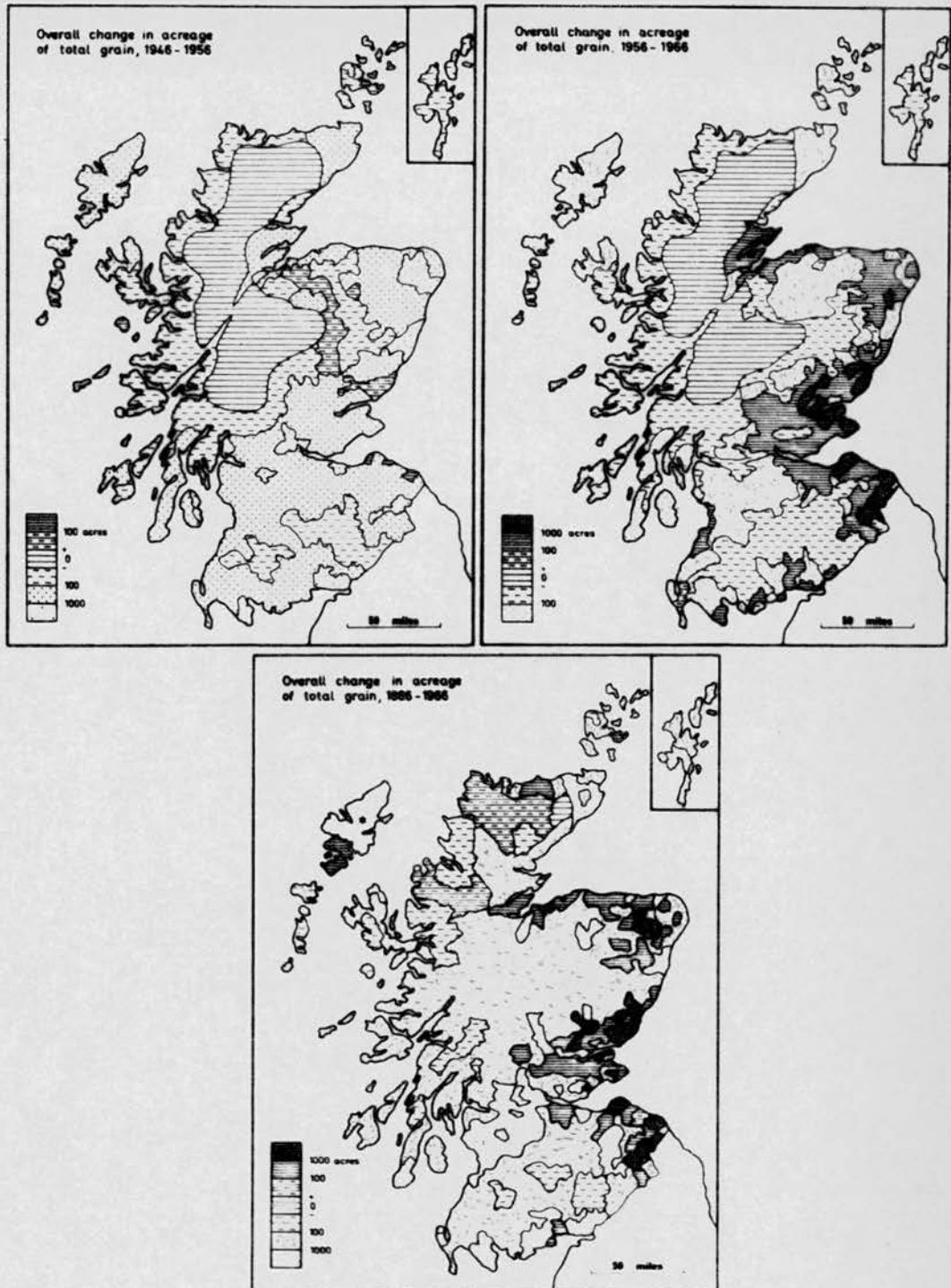


Figure 74

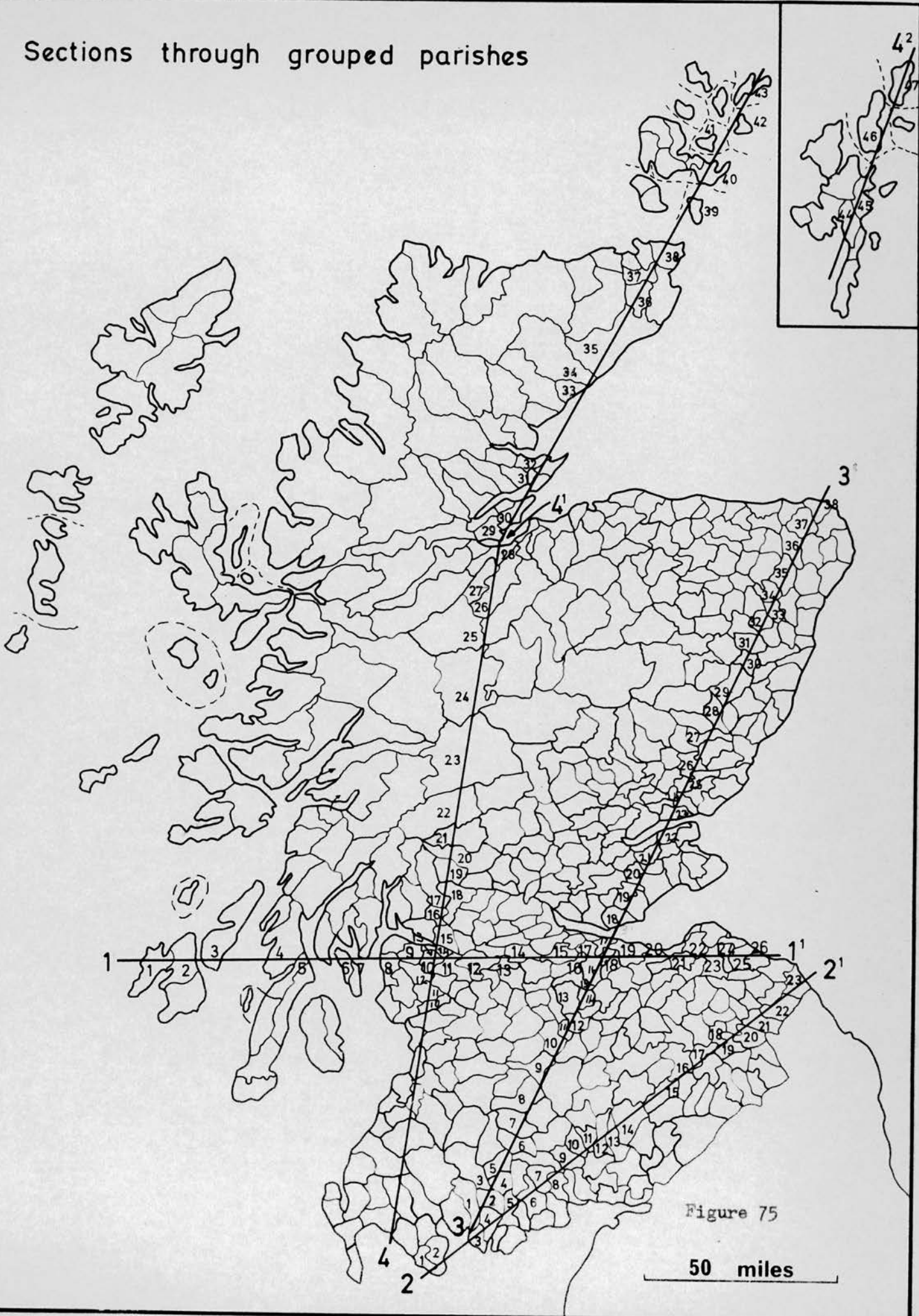
map in the large highland-uplands-islands and related areas. The 1946-1956 map is inserted to show an example of negative change in realacreage following the heavy demands on agricultural production during the war. Other examples could have been taken but these are representative and other means are used to show the situation during the gaps left in this series.

Up to this point, the static picture of grain acreage and acreage change has been presented on the parish basis. The data is not retrievable in the density shaded form and only very generally in the isoline maps. The percentage and actual acreage maps show the problems of non-comparability of areal data. Such maps may not be used unless a caution is added to their interpretation. The results are useful within limits as long as these are admitted and understood.

Equal Area Bar Graph Sections and Section Maps

The sections represented in these graphs and maps, are based on grouped, not single parishes and are designed to cut through the best as well as the poorest grain growing country (Figure 75). The key to the parishes in the section lines is found in Appendix B. The section lines cut through the Glasgow, Edinburgh and Dundee city areas and provide a changing picture in the three years 1866, 1942 and 1966 on the graphs. The equal area bar graph sections give a good illustration of patterns and are largely self-revealing. One set shows grain acreage and individual components (Figures 76, 77, 78, 79, 80, 81). Another set shows the tillage acreage in

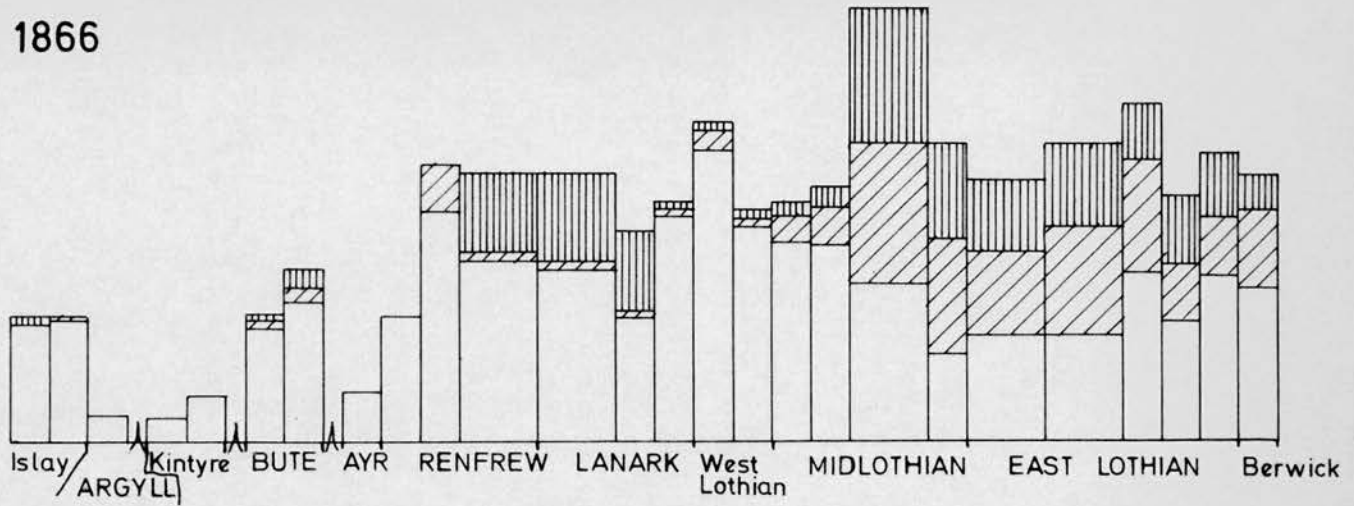
Sections through grouped parishes



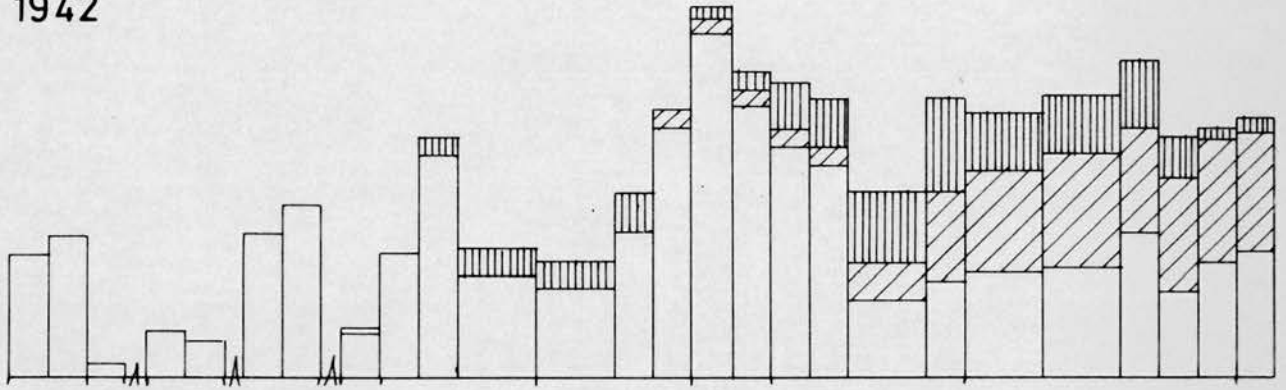
Grain Acreage

Section 1-1'

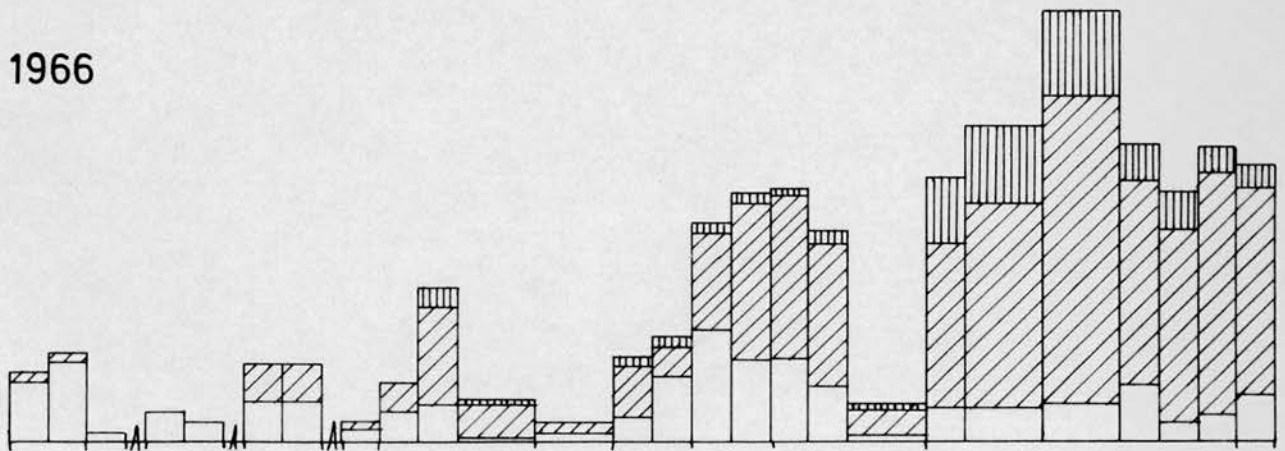
1866



1942



1966



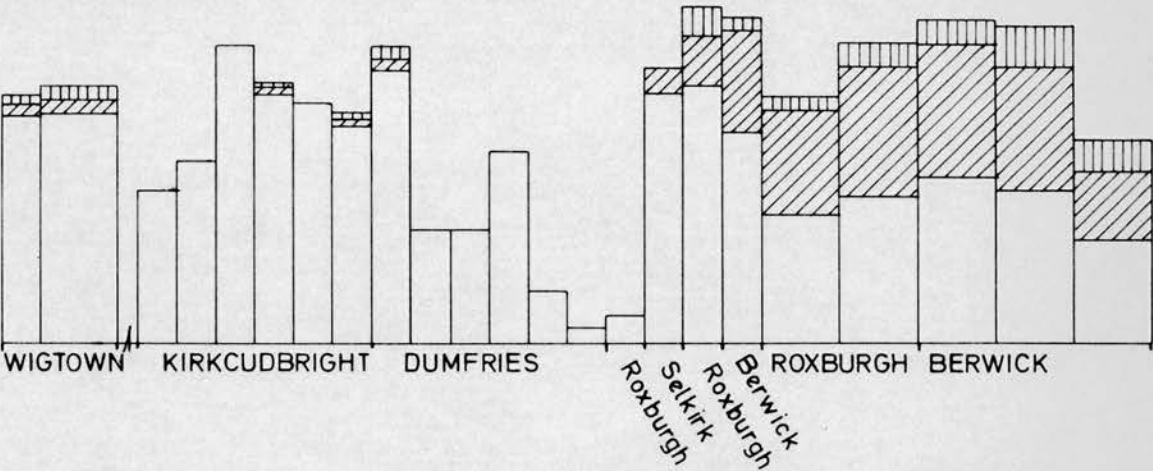
400 ACRES
 WHEAT
 BARLEY
 OATS

Figure 76

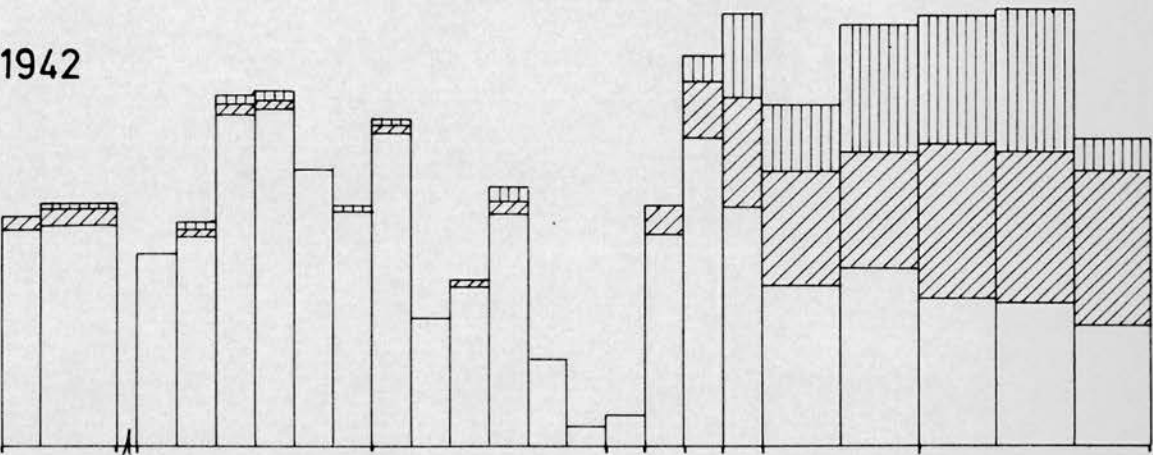
Grain Acreage

Section 2-2'

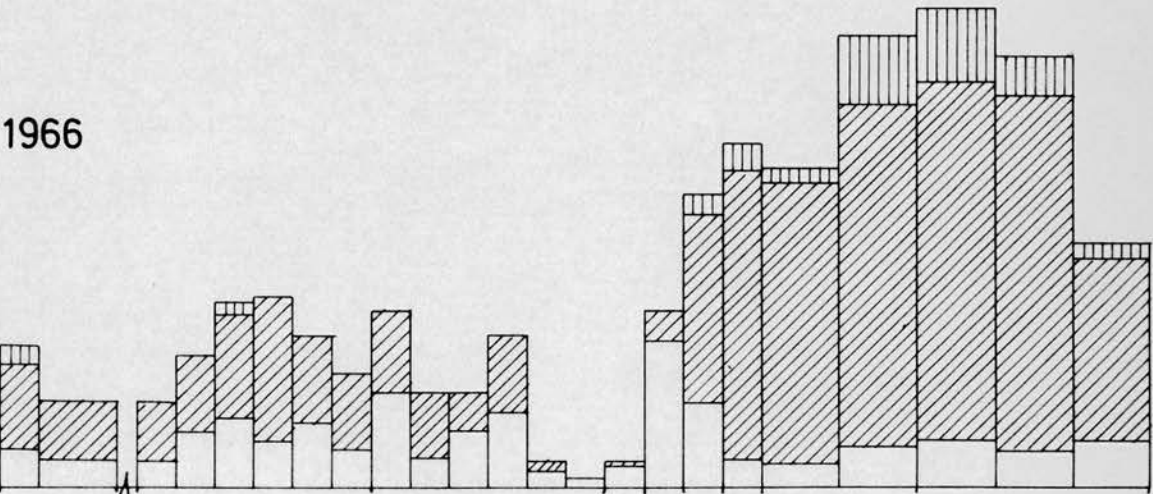
1866



1942



1966



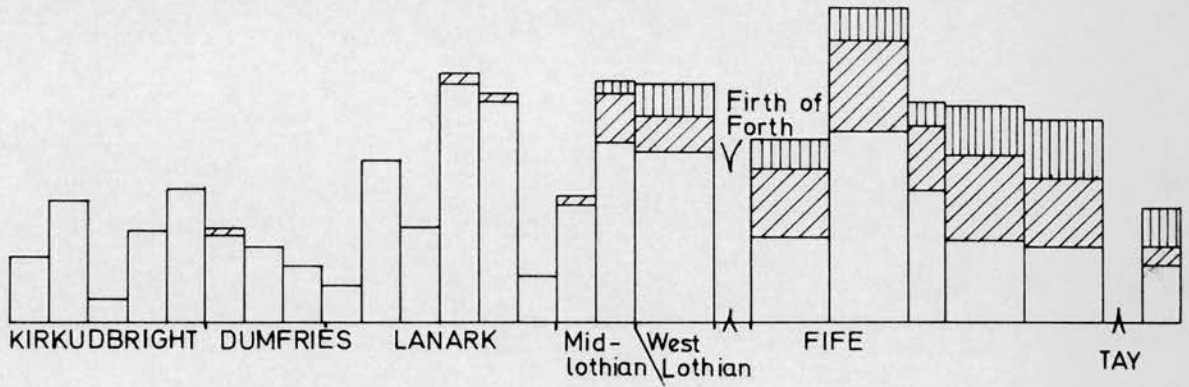
400 ACRES WHEAT BARLEY OATS

Figure 77

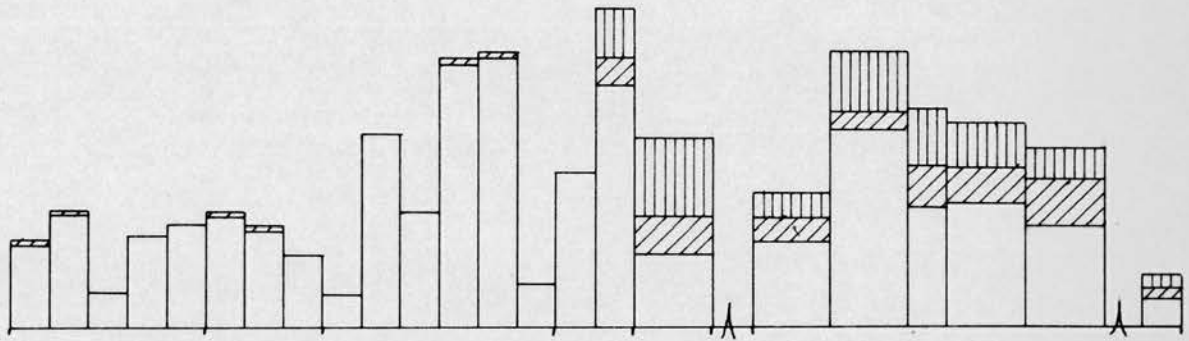
Grain Acreage

Section 3-3'

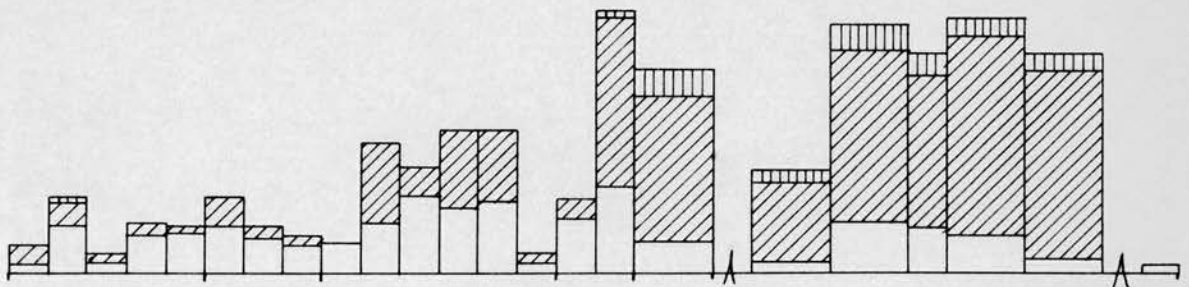
1866



1942



1966



400 ACRES WHEAT BARLEY OATS

Figure 78

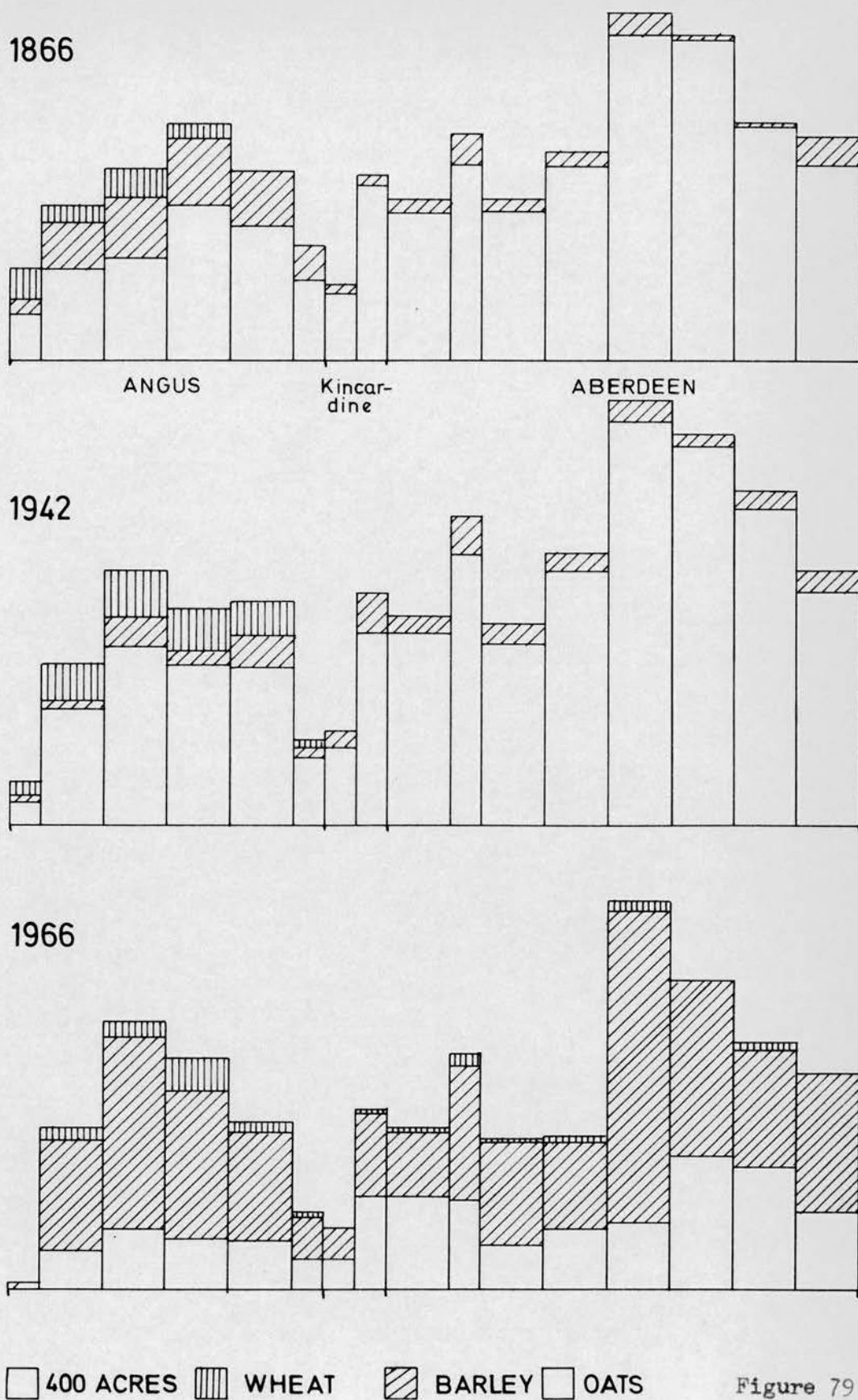
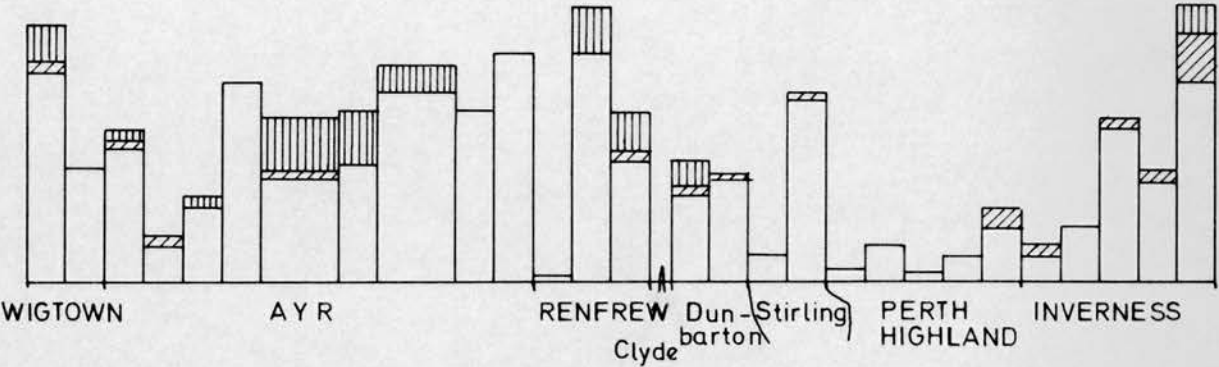
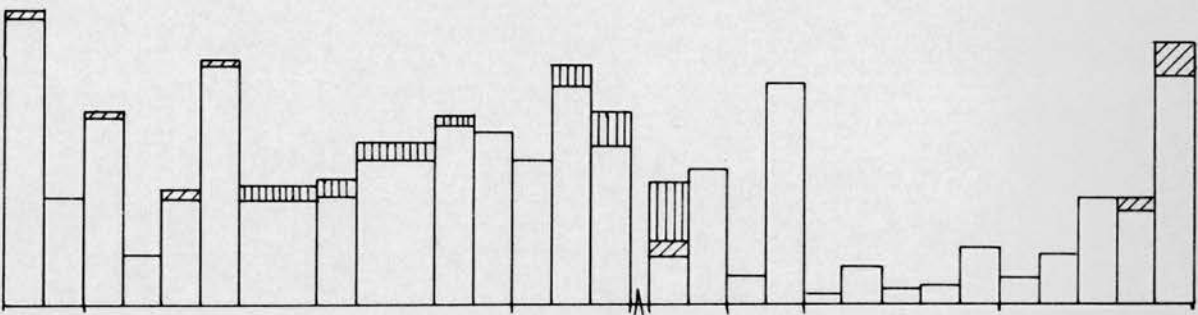


Figure 79

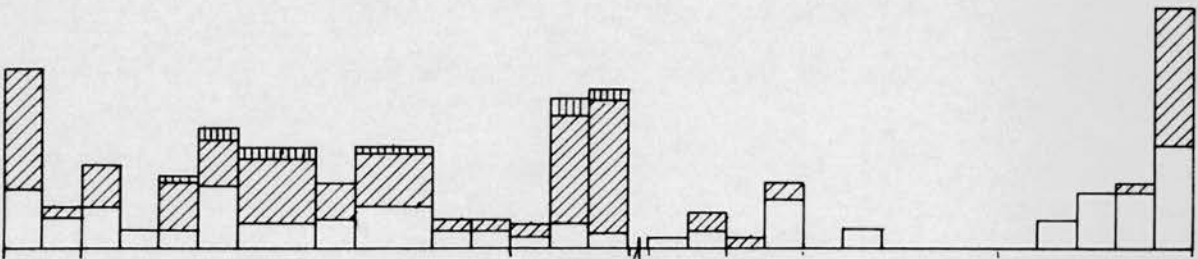
1866



1942



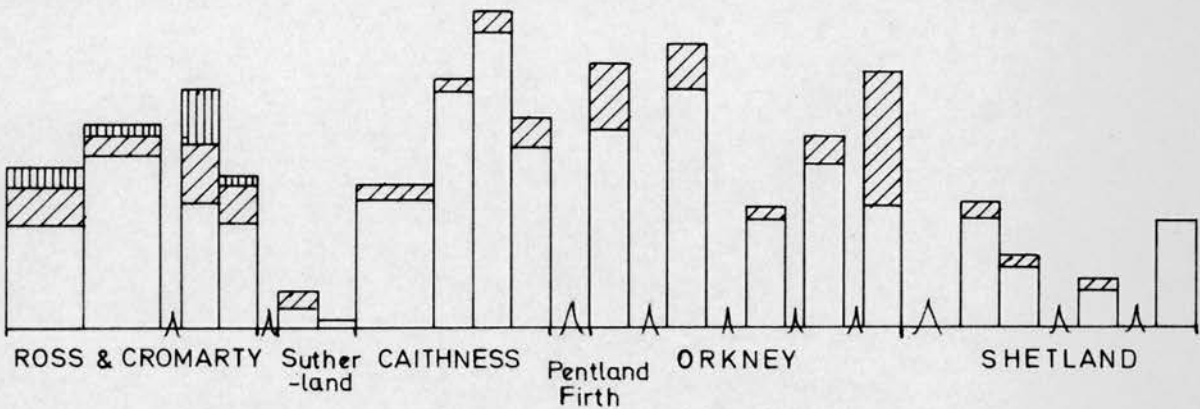
1966



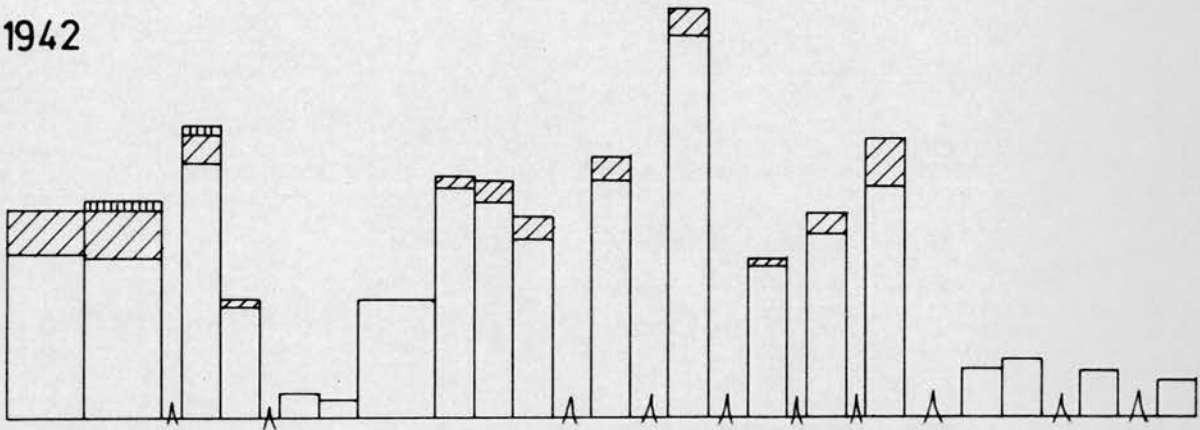
400 ACRES WHEAT BARLEY OATS

Figure 80

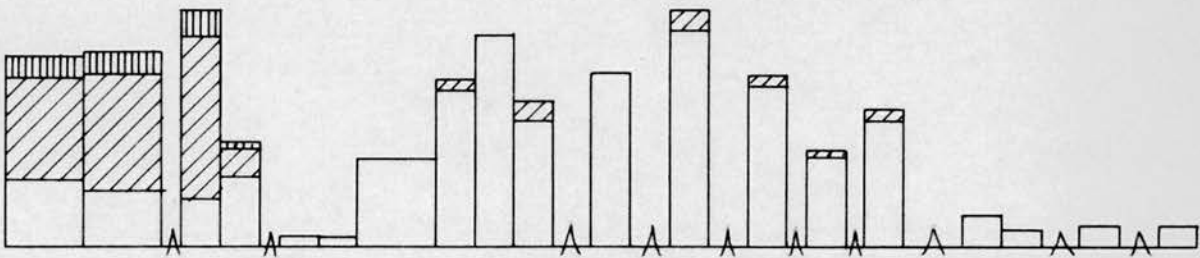
1866



1942



1966



400 ACRES WHEAT BARLEY OATS

Figure 81

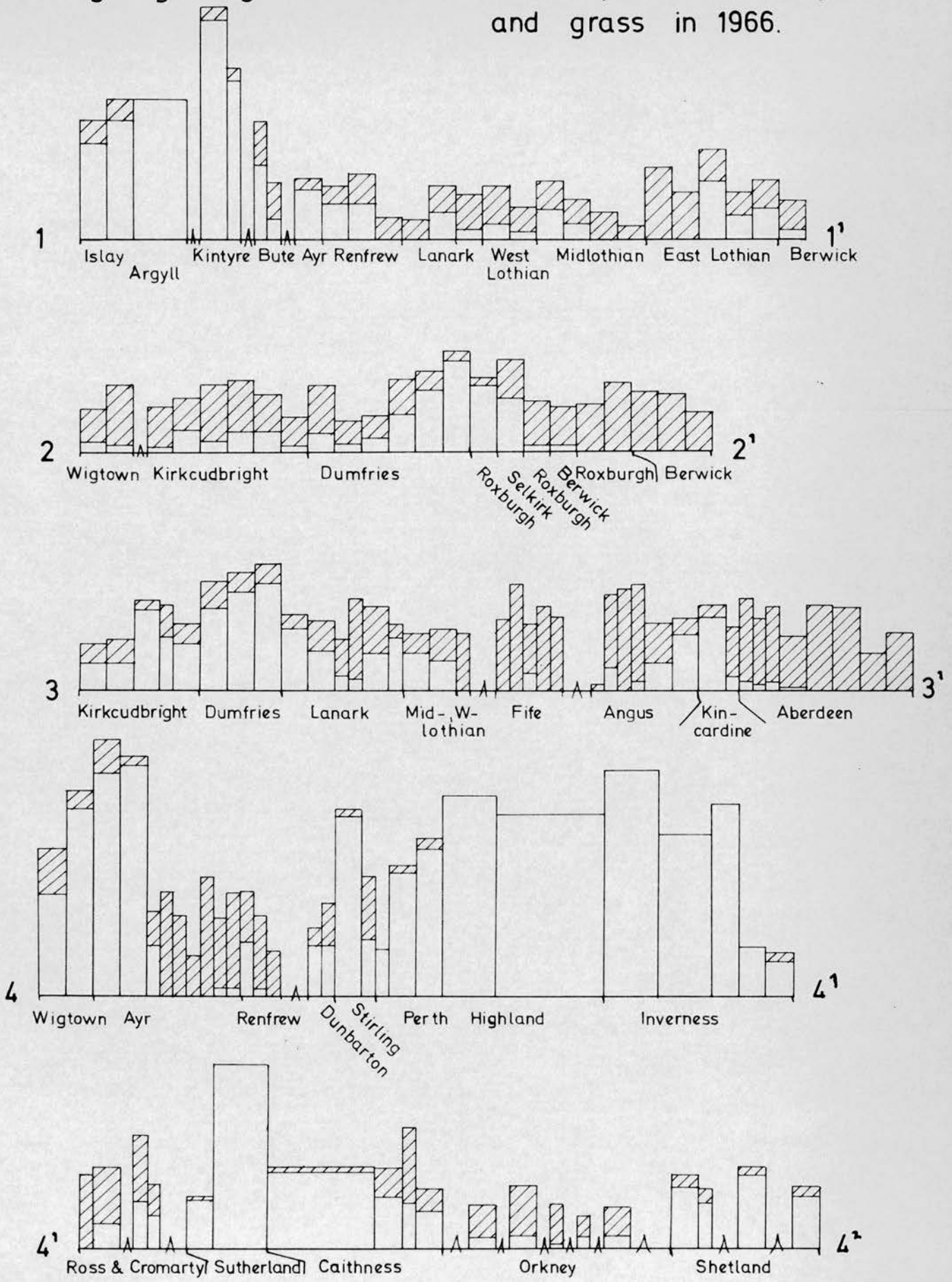
a high year 1942 and a lower one in 1946, as well as the grain acreage in 1939 and 1942 (See Figures 21 and 22 on pages 90 and 91). A third set shows the rough grazing emphasis in highland-upland areas and the crops and grass base in 1966 (Figure 82 in graph sections, Figure 83a and 83b in graph section maps). Notable points are; the shrinking grain acreages reported in the parishes at greater Paisley and Glasgow, Edinburgh and Dundee and the increase in grain acreage in the parish of Haddington, East Lothian, in grouped parishes in Berwick and Roxburgh and elsewhere. Covering a much larger area but not more significant are the sharply reduced acreages of grain reported in the highland-uplands and islands as well as the southwest.

The section maps give grain acreage in 1966 (Figures 84a, 84b and 84c) and show the sections on three pages with the bars located as precisely as possible over the grouped parishes or single parishes which the statistics represent. In addition the rough grazing section map reveals the opposite picture stressing the value of the rougher higher areas as a source of grassland even though the grain sections ascribed to them a very low value.

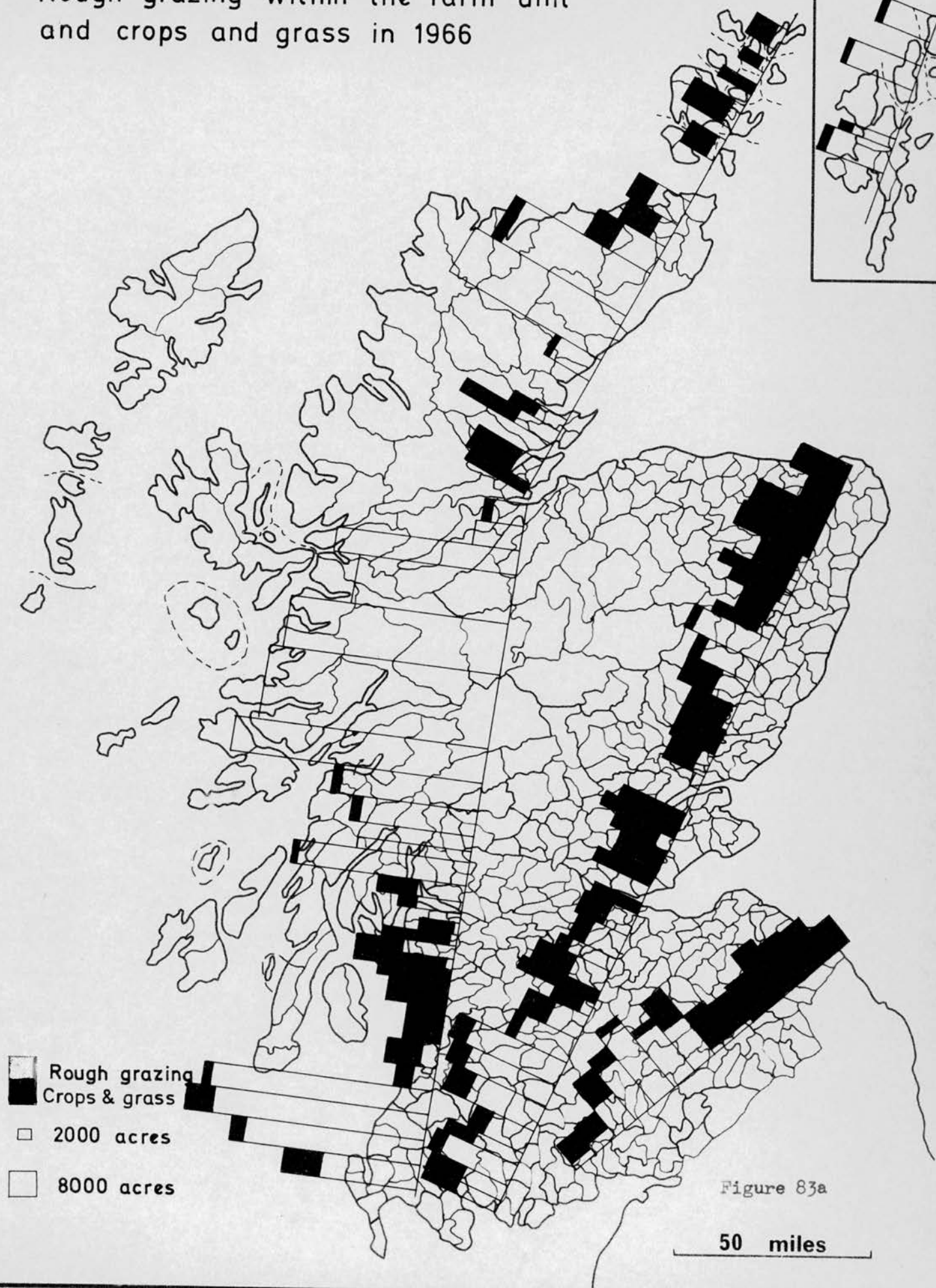
Summary

The section graphs and maps provide a most useful representation of the real situation on the ground where the variably sized parishes or grouped parishes provide the base. The parishes may be identified and the data in the equal area graphs may be retrieved in general fashion.

Rough grazing within the farm unit, and total crops and grass in 1966.



Rough grazing within the farm unit and crops and grass in 1966



Rough grazing within the farm unit and total crops and grass in 1966

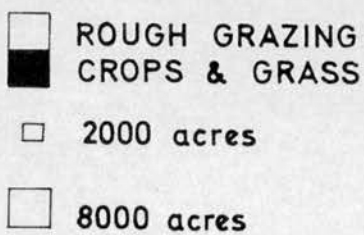
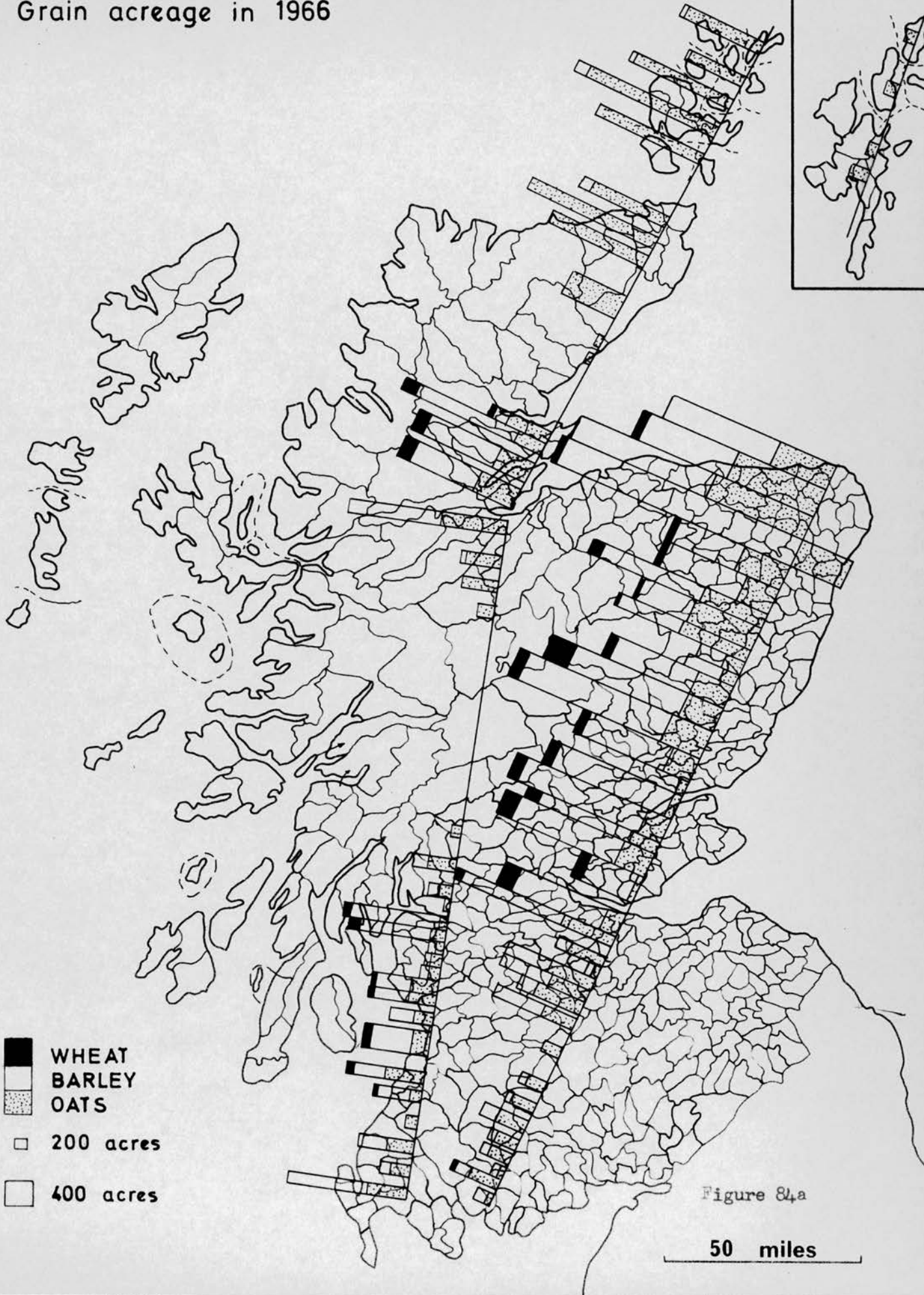
- 
- ROUGH GRAZING
CROPS & GRASS
- 2000 acres
- 8000 acres

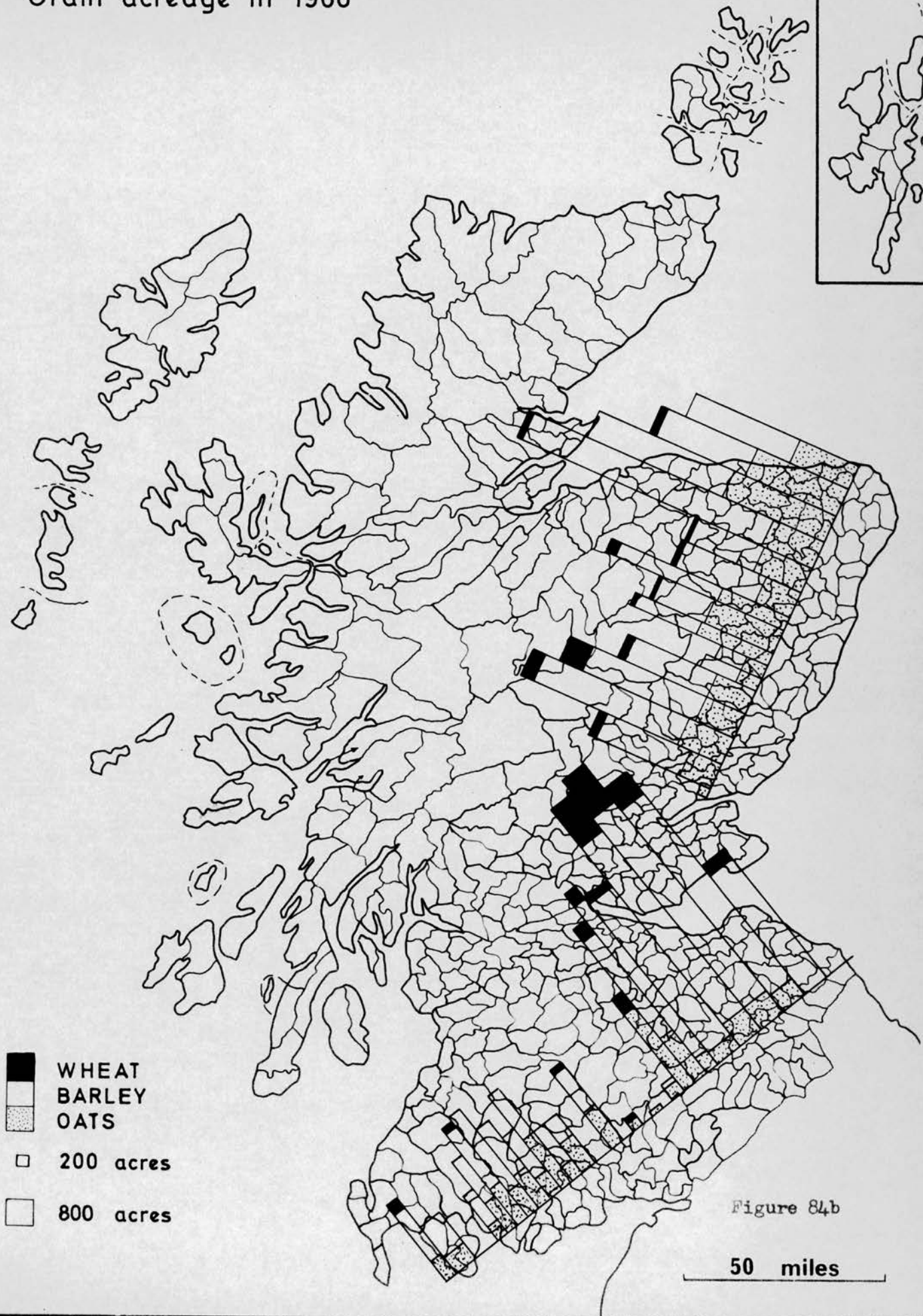
Figure 83b

50 miles

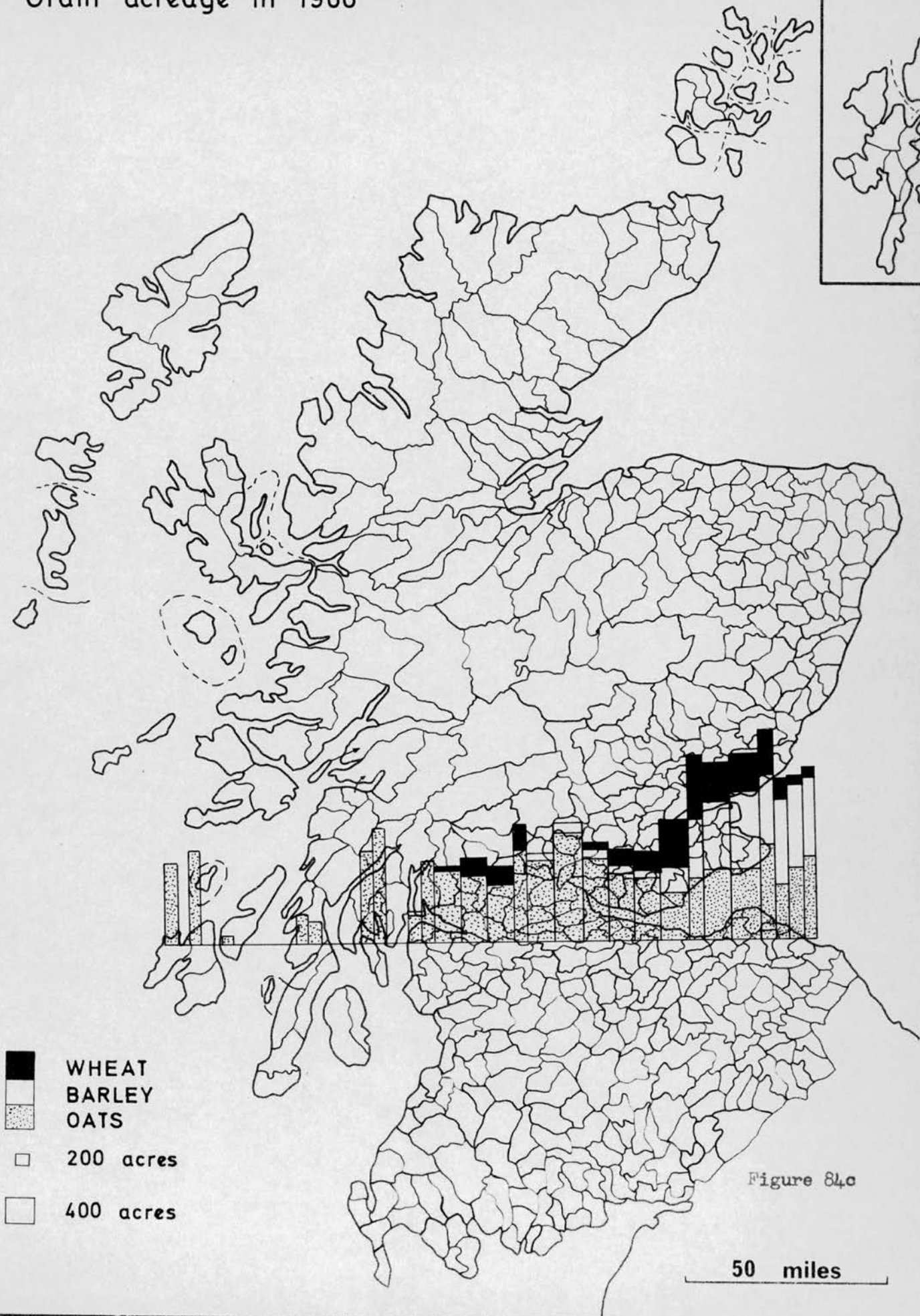
Grain acreage in 1966



Grain acreage in 1966



Grain acreage in 1966



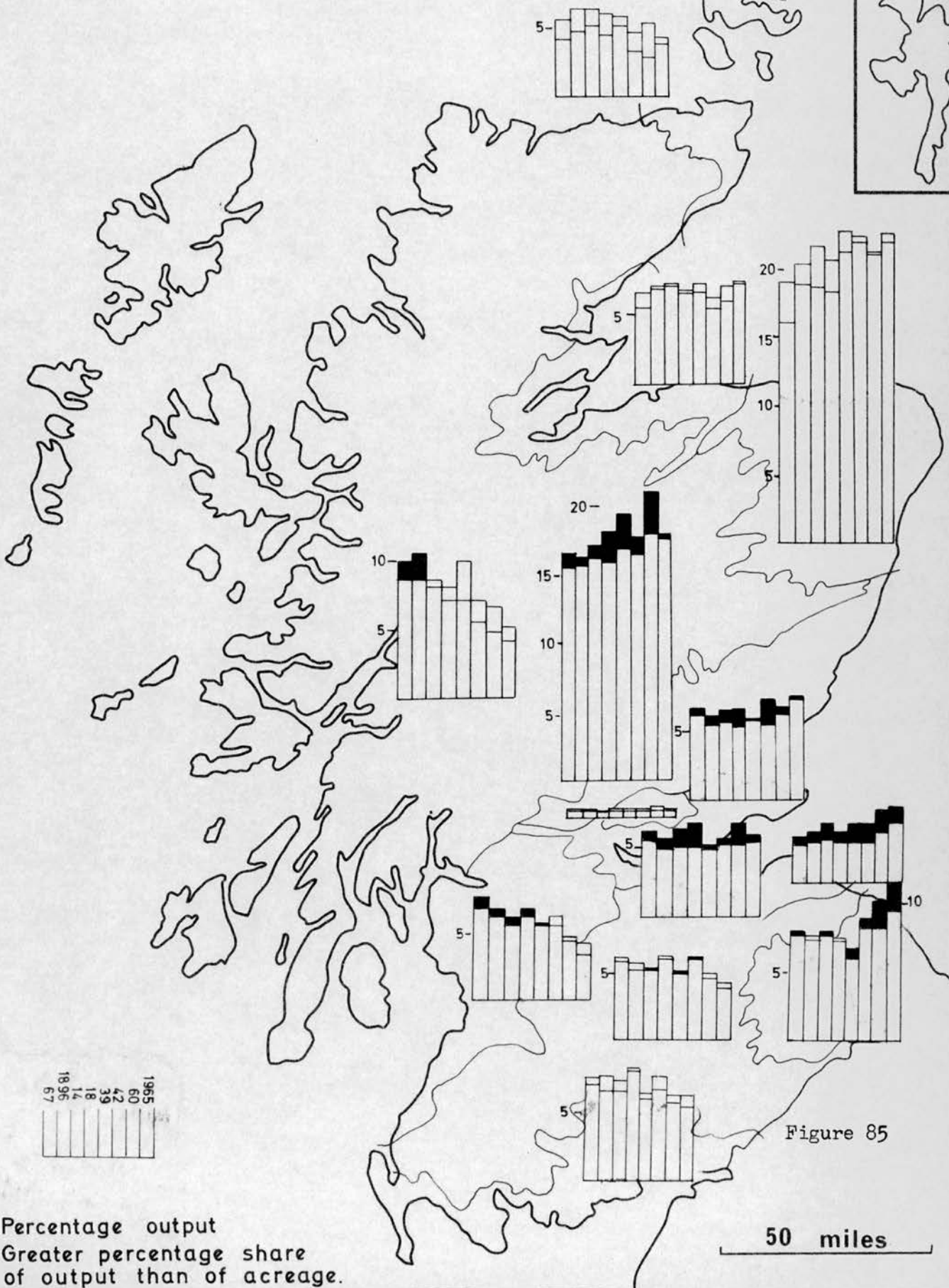
A multi-dimensional picture has been retained by subdividing the bar graphs. The unit area approach could have been used here to remove the emphasis given by the large parishes with large amounts of arable land, but that procedure has been reserved for another form of representation. This step by step approach has been adopted with a view to illustrating the different methods from common to less common forms of representation. The unit area basis approach comparing characteristic patterns by unit sizes rather than by the varying sizes of administrative units is a most useful means to real areal comparability in mapping Scotland and may be used in density shaded ratio maps and on to stepped or smoothed frequency surfaces.

Regionally Based Bar Graph Maps

The divided counties and counties make up 54 units which may be grouped into regional divisions based on the common patterns of grain growing in each. Here some sub-regional divisions have been retained to illustrate special grain crop areas such as Fife and East Lothian. These two counties contain parishes where grain crops may be interchanged when the demand arises, and in each barley was the most important crop in at least one parish over the entire one hundred years. East Lothian also grows a variety of cash crops besides grain. The Ochil Hills region has also been left separately.

The regional percentage share of total acreage and output by regions map (Figure 85) offers a clear picture in the peak, trough and more representative average years

Regional percentage share of grain acreage and output in selected years 1867-1965



chosen. The dark shaded sections on top of the main acreage bar graphs or the heavy lines across them near the top, represent the output and production superimposed over regional acreage. The regions have differing abilities to produce high yields as well as differing abilities to grow grain at all. Lowland Aberdeen and Banff often have very large acreages in grain but the yields are usually lower than the Scottish average. This fact is shown on the graph by the line cutting through the bars near the top. Other areas such as lowland Midlothian and East Lothian consistently produced yields greater than the average for Scotland so that less grain acreage was required for greater results. Such patterns are shown by the dark shaded areas at the top of the graphs.

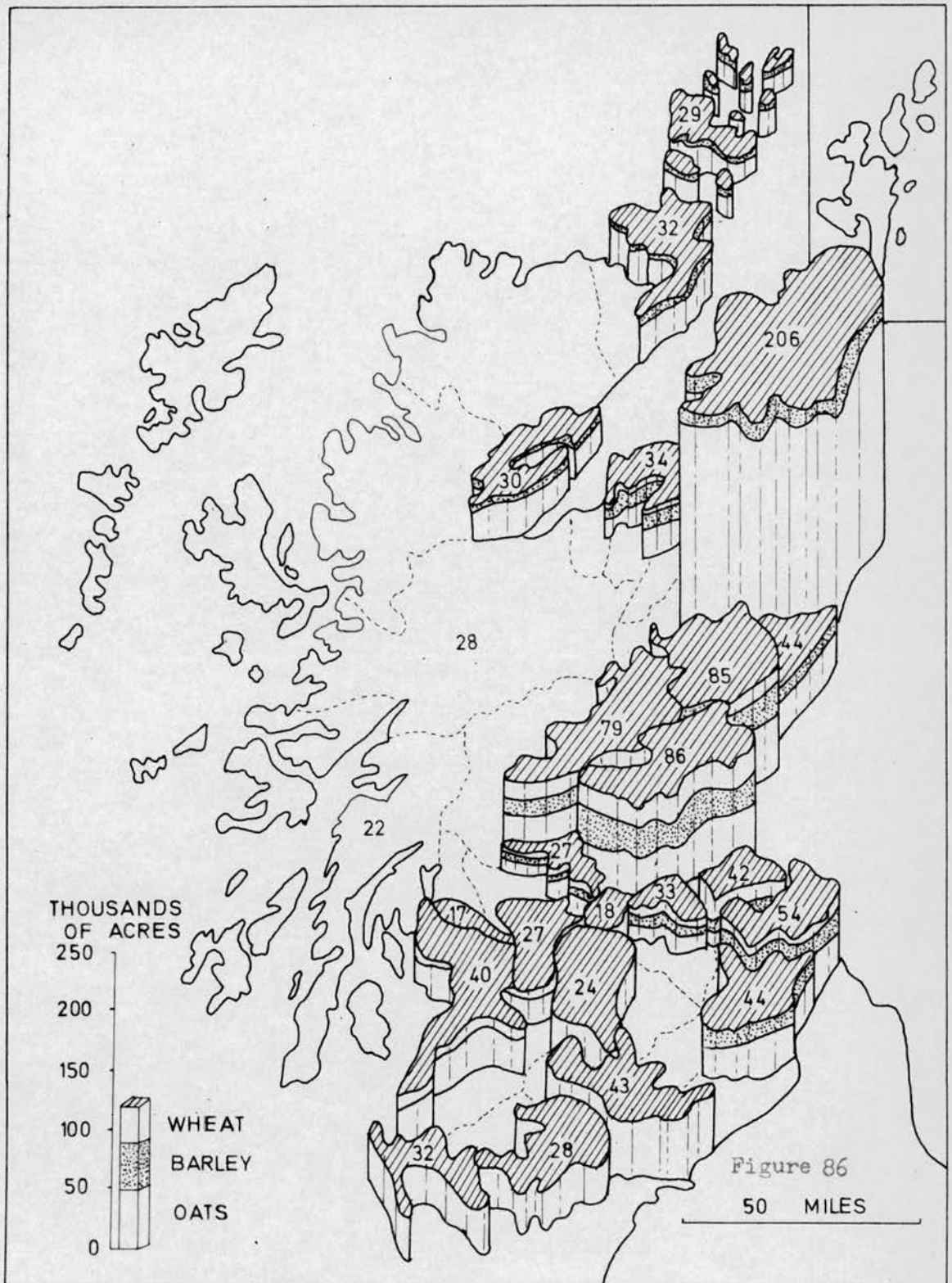
Raised Statistical Surface Maps

The total area of the arable lowland parts of the counties of Scotland have been raised to scale and subdivided to show the components of the total grain acreage situation. The only total counties represented are Orkney, East Lothian, West Lothian and Lanark. In East Lothian the Lammermuir Hills area has not been included and the grain acreage of the parishes bordering on them has been attributed to their arable parts only. Lanark has been divided but both parts are raised. The upland part has different grain components in the total and fewer alternatives to grain growing. Lowland Lanark grows more wheat, and more recently more barley and as well has a large fruit and vegetable growing industry. Unfortunately lowland

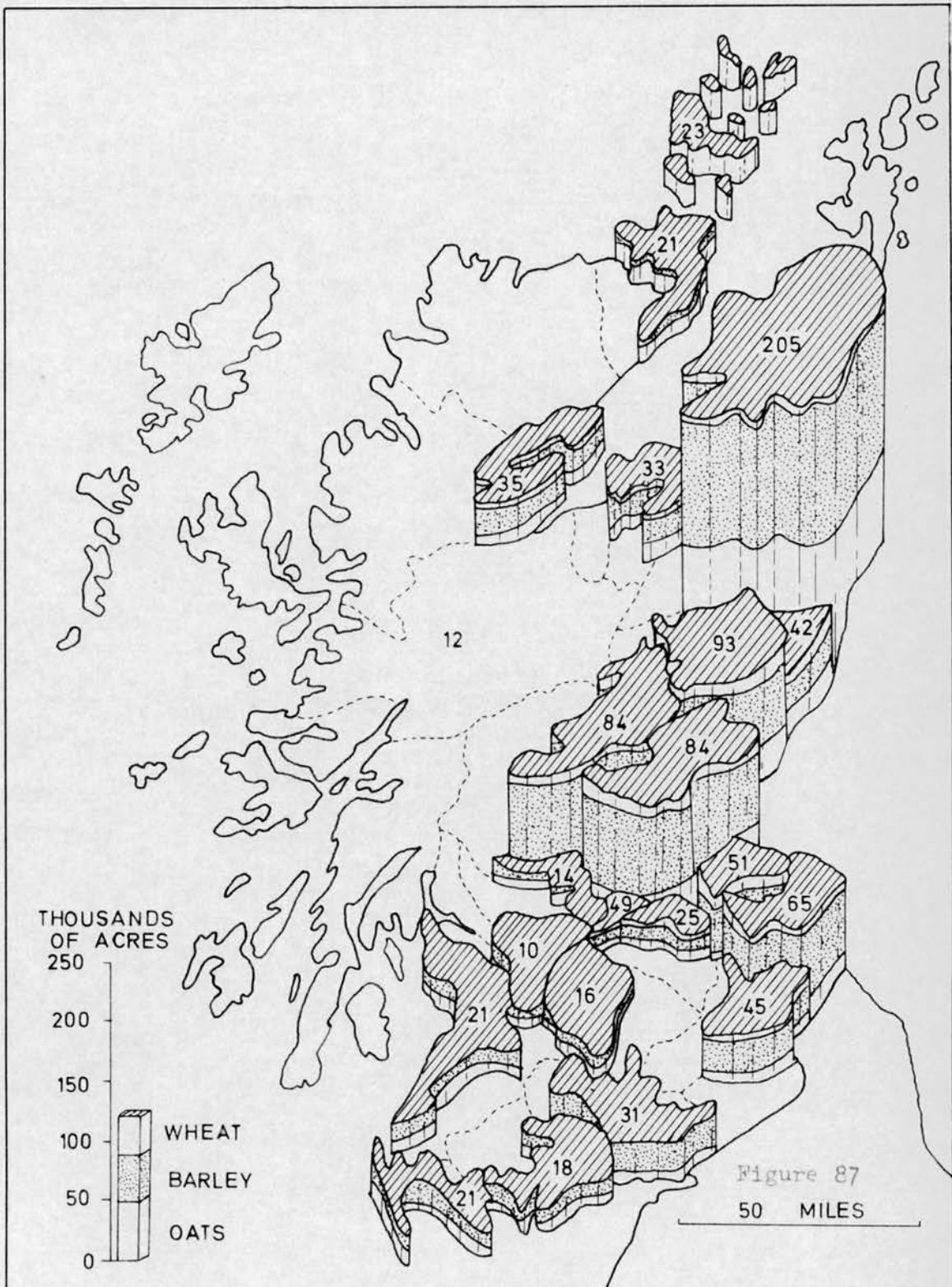
Banff is hidden by its large neighbour Aberdeen and the statistics for it must be given separately. In 1866 (Figure 86) lowland Banff had 50,800 acres in grain of which 93 per cent was in oats and 6.7 per cent in barley. In 1966 (Figure 87) the picture was considerably changed, the total acreage was down to 49,000 acres and barley occupied 51 per cent of the space and oats 48 per cent. This example is a good illustration of the changed situation in the rest of lowland Scotland.

The maps are striking in appearance and reveal the real situation accurately as long as the abbreviated acreages are supplied to assist in areal comparison. The large highland areas were not raised since they are made up of parts of a number of counties and it is difficult to differentiate between rough upland and fertile valley in them. Argyll and Inverness were raised as a whole experimentally but the results placed an emphasis on vast areas where there was little land suitable for grain cropping. Another time and at a different scale the parishes of the highland area might be raised and this would reveal that the bulk of the grain production in Argyll and highland Inverness is in Tiree, Mull and North and South Uist.

Such raised statistical surface maps are more difficult to draw and present one or two problems not evident in the idealized versions used in the texts. The shapes are not blocky in outline and in this case one large raised surface has hidden another completely, and it is



Grain acreage, by divided counties, in 1866.



Grain, by divided counties, in 1966

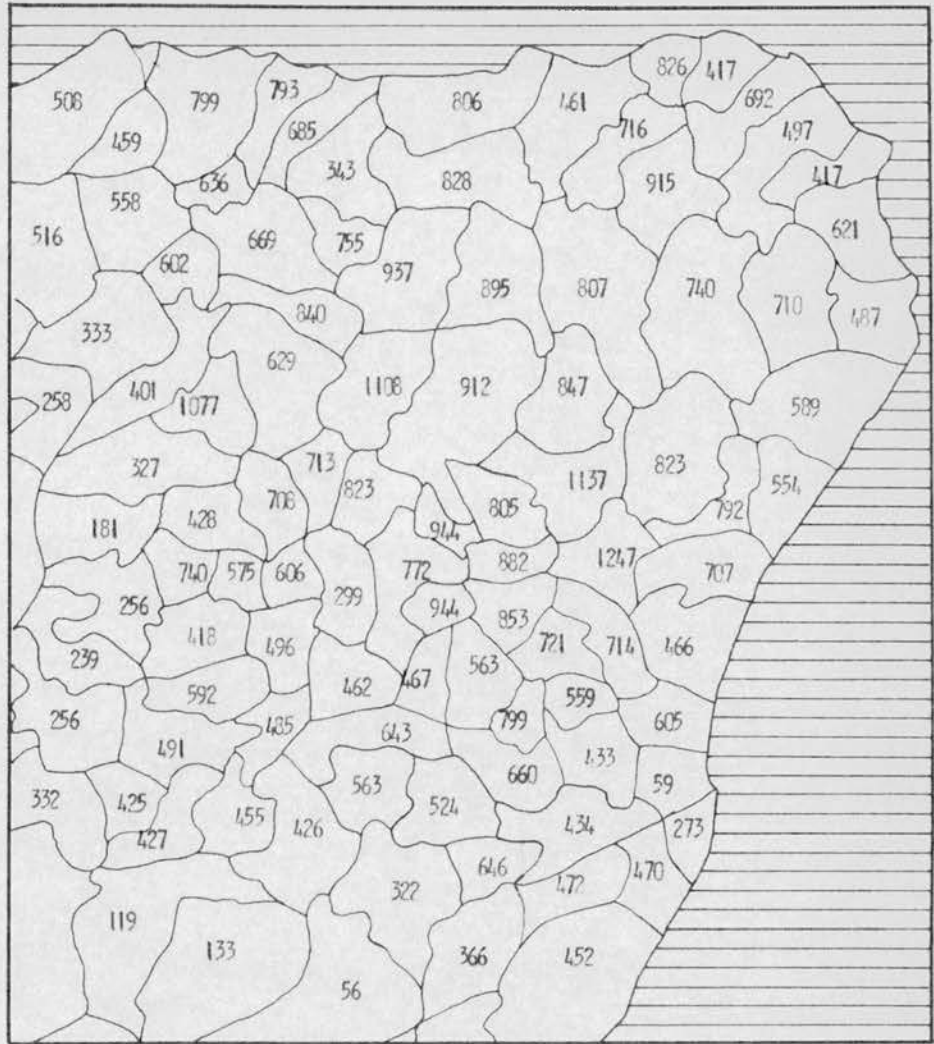
difficult to measure oats or total grain using the vertical scale on lowland Perth or East Lothian. These drawbacks could be overcome by providing maps based on more than one vantage point. Despite the problems raised surface maps offer valuable visual detail and serve to emphasize regions already known to be productive but in a useful vertical scale order.

Unit Area Stepped Frequency Surface Diagrams

The unit area approach is not a new one but it is not widely applied. The samples used here and in the methodology section show how versatile they are for representing any type of population for which statistics may be uniformly gathered. The approach is highly adaptable to the mixed surface situation of arable lowlands and rough highland-uplands to be found in Scotland on the whole country, the county or the parish scale.

As an example, a unit area grain diagram and key map to the scale on the map of 1:625,000 is presented here for all of arable Aberdeen and parts of adjacent Banff and Kincardine (Figure 88) and for a similar sized area on the south side of the Forth, including most or all of Midlothian, East Lothian, Berwick, Roxburgh, Selkirk and Peebles (Figure 89). Each block in the diagram represents the characteristic acreage to be found in an area on the ground amounting to 14.7 square kilometres. A millimetre vertically represents 50 acres of grain.

A problem in preparing such diagrams where there are a multitude of tiny parishes, is their ordering in roughly



1 unit = 5 mm² or 14.7 sq.Kms

(1:625000)

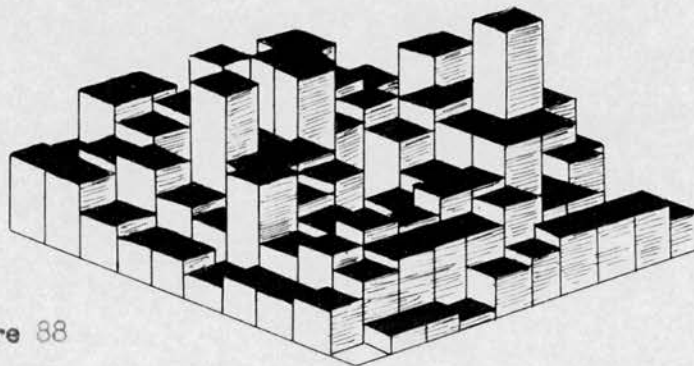
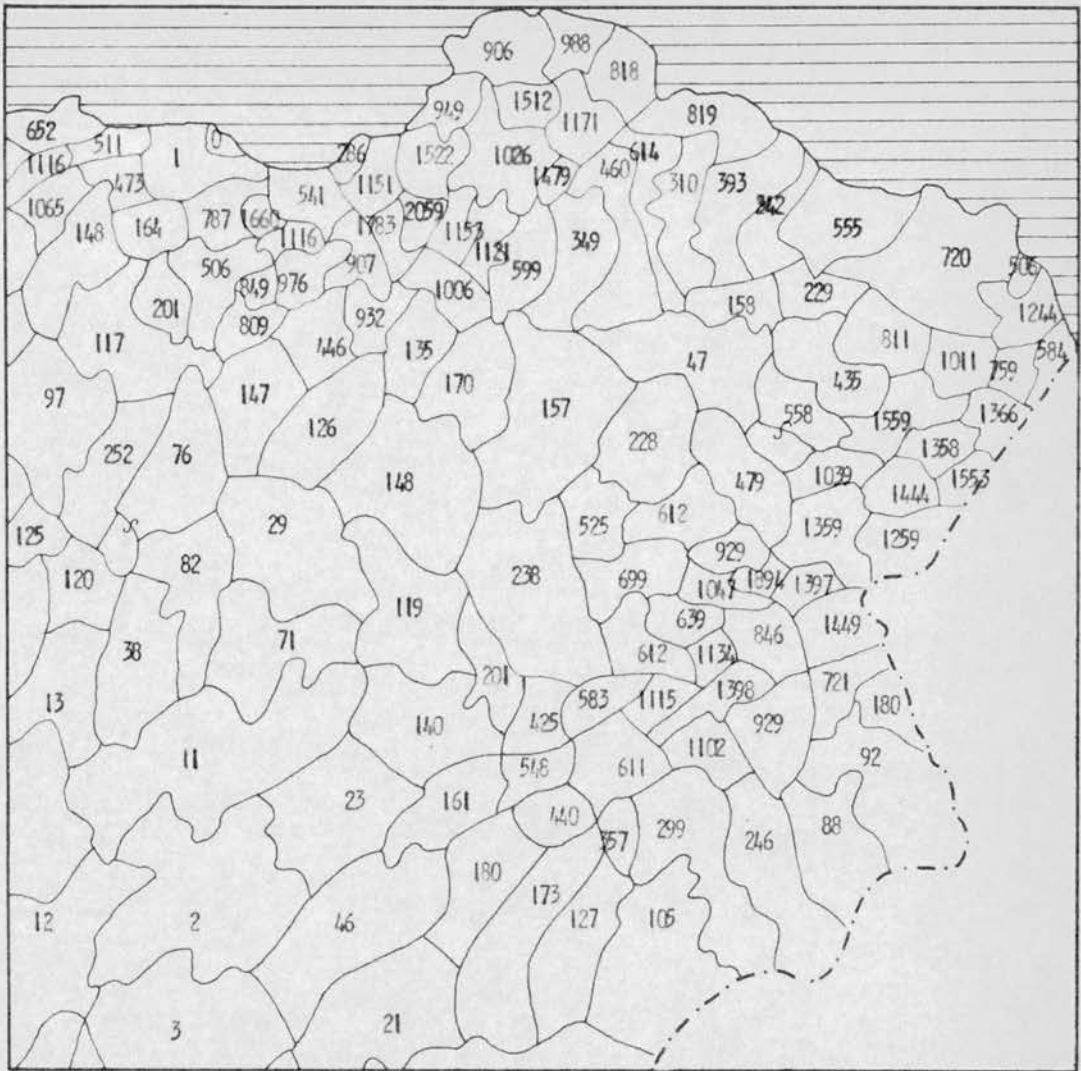


Figure 88

Vertical scale- 1mm. : 50 acres

Total grain acreage per unit area in 1966



1 unit = 5mm² or 14.7 sq. Kms

(1:625000)

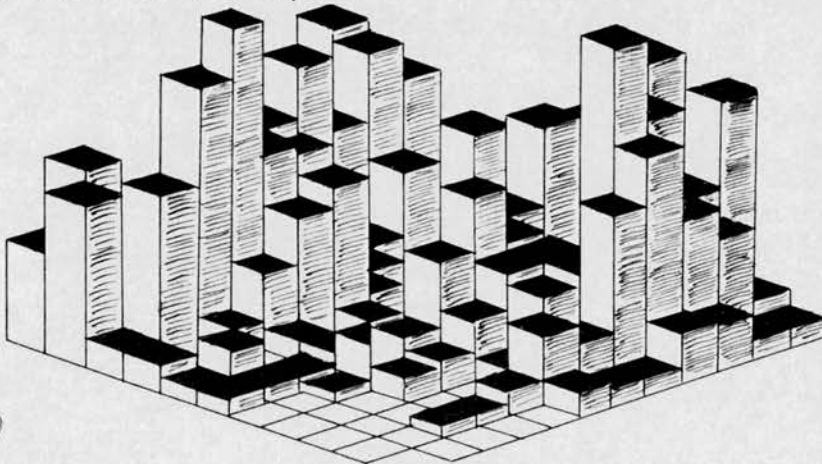


Figure 89

Vertical scale- 1mm. : 50 acres

Total grain acreage per unit area in 1966

parallel rows in conformity to the actual situation on the ground. Some concessions have had to be made, to include some parishes in one row rather than on another, or to move them somewhat along the row on the diagram. Despite these problems the main facts of the physical landscape have appeared through the diagram. Low acreages are where they are expected and the vantage point is from the southwestern corner in the grain diagrams and this aids in visual comparison.

In practice, when this approach to mapping is chosen, more than one vantage point would be presented so that sections hidden by tall raised block surfaces would be visible. The northeastern viewpoint was taken when preparing the rough grazing diagram. The data on which the diagrams is based is available in any case on the key maps.

Stepped frequency surface diagrams may be programmed and obtained in stylized fashion from a computer. The examples have been left as stepped frequency surfaces because too much detail was lost when the samples were smoothed. If smaller areas were chosen such as the Merse of Berwick, a typical trend surface with curves rising to the centre of the block would result. To present trend surfaces at their ideal best, stepped frequency surfaces may be drawn first and then suitable areas isolated and drawn separately, shorn of the isolated blocks which complicate and restrict the view. (The other unit area stepped frequency diagrams may be found on page 116 and following, and the individual examples for wheat, oats and barley are used in the sections under those headings.)

Stepped Frequency Surface Block Maps of Scotland

The final approaches to the presentation of the real grain pattern of Scotland has been entered at this stage. A parish map of Scotland was converted into a map of verticals by scaling the acreages by parishes, to one centimetre to 1,000 acres. Then the dominant verticals were placed on a large parish map of Scotland (1:625,000) in the form of square centimetre wooden blocks. Only the parishes with acreages greater than 2,000 acres are represented at the scale chosen and 130 are representative of the larger lowland parishes. Others could have been represented as well but the umbrella effect of the larger verticals covered the others when a net was placed on the map. The presentation reveals a parish sample situation of the total map of Scotland (Figures 90 and 91). The largest grain acreages are to be found in the arable parts of Aberdeen, Perth and Angus, on both sides of the Firth of Forth, in the Merse of Berwick and lowlands of Roxburgh and so on. However, the emphasis is on the large arable parishes. Grouping of small numbers of intensively arable parishes into larger more comparably sized ones only served to accentuate the problem of areal differentiation and increased the height of the blocks.

The unit area approach was then applied and a second model constructed using a greater number of parishes because there were less dominant heights and the stepped frequency surface was to be maintained to show the slight differences in vertical pattern. The lowland parishes were represented

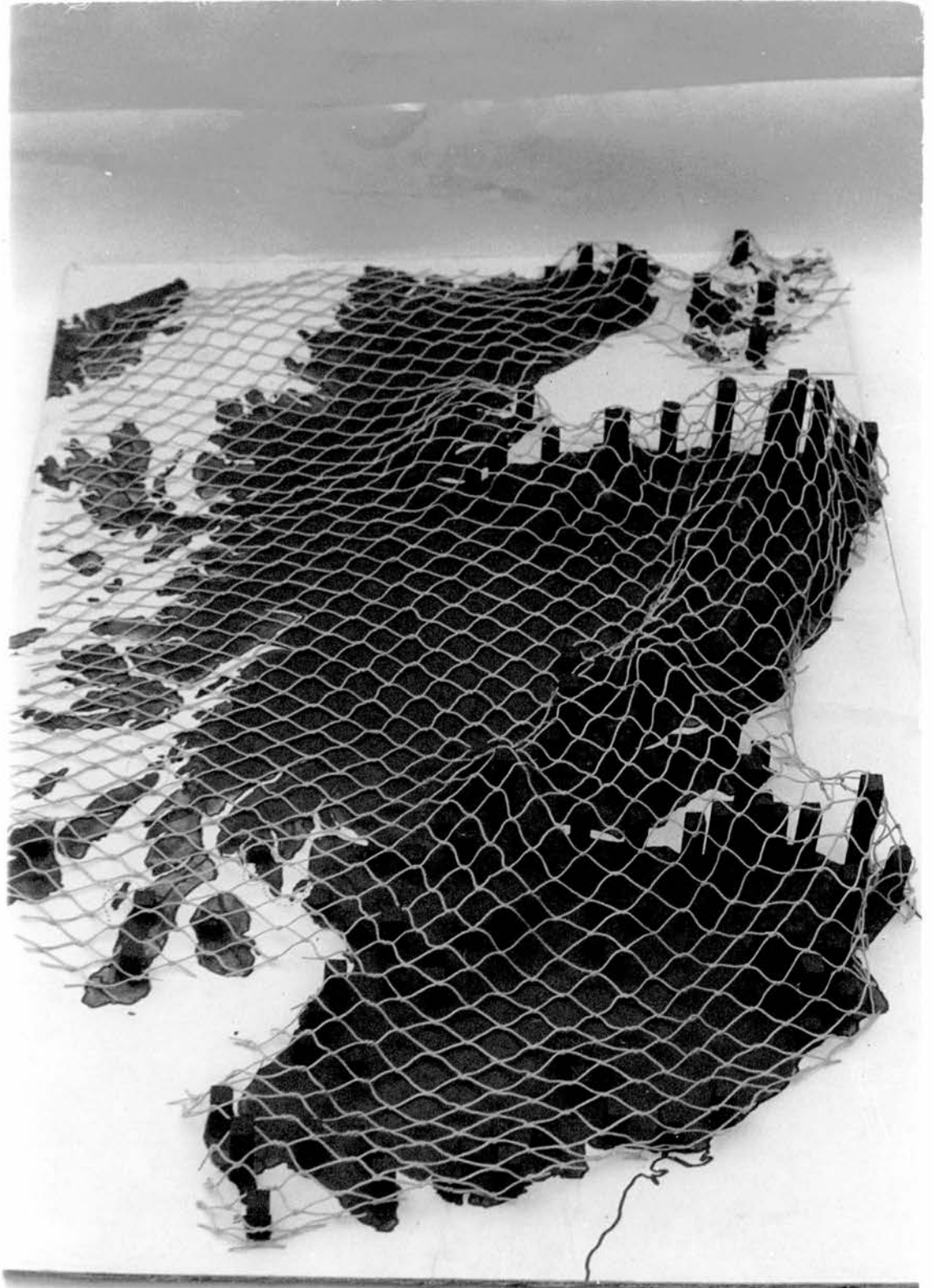


Figure 90



Figure 91

by 210 parishes (Figures 92 and 93). More might have been used but the size of the blocks prevented it on this scale of one centimetre square blocks, and no more could be crowded on in the areas where the scale of grain growing by unit area characteristics was representable.

The results are outstandingly successful and the concentration of grain cropping from Angus southward following the jagged coastline around the Firths of Tay and Forth to Berwick, is given greater prominence. This is in accordance with statistical realities, since the characteristic grain cropping of the parishes in this coastal area is more concentrated than in Aberdeen. Where the first model overstressed the grain acreages in large parishes of lowland; Aberdeen, Banff, Moray, Nairn, Inverness, Ross and Cromarty, Caithness and Orkney in the north, and Ayr, Dumfries, Kirkcudbright and Wigtown in the southwest the unit area model offers a more balanced approach and the wide variations in administrative unit sizes is overcome. The photo-reduction of the models has made measuring to scale difficult. However the models are presented on the countrywide scale in order to give total visual impact. Smaller areas may be shown separately drawn to scale as in the diagram models of arable Aberdeen and south of the Forth. All of the categories represented in the latter areas may be presented on the Scotland map. (Other populations in restricted areas, such as industry in urban regions, may be shown in the same unit area approach on the national scale, by parishes or the parts of them concerned.)



Figure 92

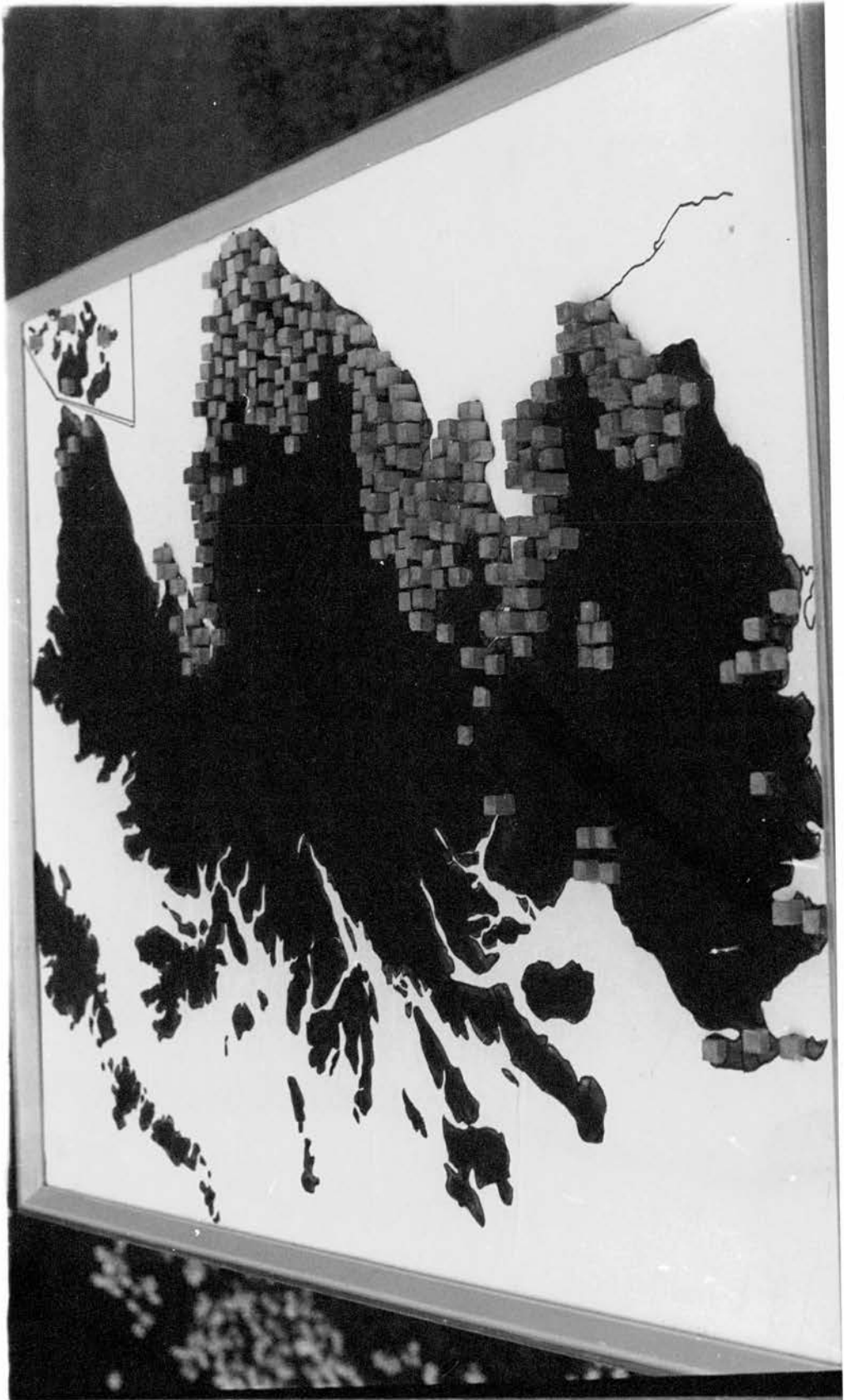


Figure 93

Summary

The changing patterns of grain farming in Scotland have been presented in ten or more different forms from line graphs to stepped frequency surface diagrams. Ideally the unit area approach would have been used in most of them. The division of most of the counties into lowland and upland parts is a useful general approach which helps to separate better arable parishes from hill parishes. The best continuous historical picture of pattern 1867-1966 is revealed in the line graphs for one county or divided county at a time. The number pattern maps 1867-1966 give the 54 unit division of Scotland in any one year. Unit area models of the whole of Scotland could be prepared for every year as well and the one for 1966 is only a sample of the possibilities.

While increasing percentages of crops and grass acreages have been devoted to grain cropping, farming has become more intensive in the better arable lowland areas in the decade 1956-1966, the uses of the abundance of grass in the vast remaining areas has not kept pace (possibly with the exception of predominantly dairying areas in the west and southwest particularly). The technical progress of the arable farmer helped by crop research and better, more adaptable grain varieties has been on a far greater scale than the technical progress of turning grass into milk or meat.¹ This is probably because grain farming is

¹ According to Amey, L., Where Prices may curb expansion, Farming Topics, The Times, March 11, 1968. This view from the Press obtained its substance from such sources as Cooper, M., McG. Dean of Agriculture, University of Durham, in the Foreward to Voisin, A., Grass Productivity, Crosby Lockwood, London 1959, page v.

a shorter term activity before a profit can be taken than many other farming specialities. Grain farming may be begun quickly and left just as quickly, though when labour is scarce, mechanized labour involves an expenditure which inhibits such a practice. In order to take the harvested grain into storage and keep it at a premium quality until sold, grain driers and specially constructed storage bins are required.¹ Recent experimentation has shown that moulds, diseases and parasites which cause grain deterioration in storage may be inhibited if grain is kept cooler than 40 F.² Such elaborate equipment installations have been helpful in keeping the grain output of many Scottish farms at the peak of quality and it is notable that feed grains find such a ready international market.³ This fact explains to a great extent the recent switch from alternative crops or from other grain crops to barley. Grain growing has been maintained in remote areas because there are no alternatives to grain for a cash crop that may be stored and those areas are farther from the markets and do not respond rapidly to short term changes in market demand. The result has been to create some fascinating patterns of grain distribution.

1. A description of such storage set-ups was provided by Mercer, D., Plant will assure grain supply, *The Scotsman*, August 11, 1967, in a special section on Malting.

2. An item from the agricultural correspondent on Refrigerated Grain Storage, Agricultural Section, *The Times*, August 28, 1967.

3. This view is expressed in a press item, *Britains Cereal Harvest likely to reach 14 million tons*, *Industrial News*, *The Times*, September 19, 1967. The claim was made that British barley is of a much superior quality to European barley and this claim is supported by the purchasers of the grain.

The Changing Pattern of Wheat Distribution
Line Graphs 1867-1966

The divided county and county graphs (Appendix C) quickly reveal that wheat is grown only in the more arable parts of 20 counties and with varying success even there. This "being a reflection of the fact that the cultivation of this crop is virtually restricted by climatic conditions to the best arable land in Scotland. Variations due to climate and soil are, therefore, almost eliminated so far as wheat is concerned."¹ Writing in reference to the previous century in 1866, Thomson stated "The amelioration of climate which the cutting down of growing timber, the drainage, and the cultivation of the past century have effected in Ayrshire, has enlarged the wheat zone from small patches in early or sheltered localities to all drained lands under an altitude of 300 feet; and on most farms, now-a-days, under 200 feet, where the soil is suitable, wheat has become a regular crop of the location."² This statement out of the past touches on a key point, concerning the alteration of local climate patterns as land use practices change.³

1. See page 40 in Scola, P.M., and Catt, D.C., Yields, Stocks on Farms and Disposals of Cereals in Scotland, Scottish Agricultural Economics 16 (1966) pp. 39-41.

2. From page 344 in Thomson, R.G., Experiments with Different Varieties of Wheat in 1864 and 1865, Transactions of the Highland and Agricultural Society of Scotland, Vol. 1, 4th Series, 1866-1867, pp. 344-357.

3. A discussion of man's role in this may be found in Watson, J.W. Forest or Bog: Man the Deciding Factor, Scottish Geographical Magazine, 55(3) 1939 pp. 148-161. The paper also discusses the effect of latitude, the correlation of rainfall and relief and vegetation, problems of drainage, differing conditions of insolation, exposure and slope on growth conditions and so on. These factors and others help to limit the growing of wheat in the west of Scotland where the paper was based.

In the west, grain harvests are often delayed by wet weather. "Great local demand for wheat was insufficient to overcome the physical drawbacks to its cultivation. The shortness of the growing season and the liability to early autumn frosts ensured that this crop, like beans, only appeared to a small extent in the northern parts of the rich haughlands."¹ In spite of the less favourable of these opinions, a recent recommendation has been for more wheat growing in Scotland.²

In the north and east, a new development has altered the grain growing patterns in the last decade of the hundred years, when up to 13,100 acres of wheat was grown in one year for very nearly the first time in Aberdeen. In a narrow band of eight adjacent parishes; New Machar, Udney, Logie-Buchan, Ellon, Old Deer, Longside, St. Fergus and Peterhead, the largest acreages of the total were reported. This land use change is undoubtedly due to the use of the new varieties³ recommended for the region. Wheat acreages in Kincardine varied from 300 to 2,500 over the century, in lowland Moray from 400 to 6,000, lowland Inverness from 1 to 1,800 and in lowland eastern Ross and Cromarty from 500 to 10,000 with the last 35 years ranging from 500 to 3,000.

1. Snodgrass, C. P., Lanarkshire: The Agricultural Geography of a Scottish County, The Scottish Geographical Magazine, 53(3) May 1937, pp. 176-199.

2. Urquhart, R., Barley Surplus could bring Switch to Wheat, Farming Scene, The Scotsman, March 2, 1968. This Press report was based on the Home Grown Cereal Authority recommendations.

3. Some of these were listed for this part of Aberdeen by Kay, G., Agricultural Patterns and Soil Types in North-East Scotland, The Scottish Geographical Magazine 77(3) December 1961, pp. 131-147.

In the southwest, wheat acreages in lowland Ayr varied from a few acres to 1,700 over the century or from 700 to 1,700 in the last 30 years; in lowland Dumfries from a few to 2,500 acres mainly since 1932; in lowland Dunbarton from 1 to 2,000 acres; in Renfrew from 400 to 3,000 with the lowest period being from 1945; and in lowland Lanark 200 to 3,000.

The main wheat growing regions are in the eastern lowlands around the Firths of Tay and Forth and in the Merse of Berwick and neighbouring lowlands of Roxburgh. The lowland part of Angus had wheat acreages of 7,000 to 12,500 over the century; lowland Perth (Figure 94) 3,000 to 18,000 but generally over 6,000 acres since 1932; Fife 7,000 to 18,000 acres; lowland Stirling in the Forth grain region 1,000 to 5,000; West Lothian 800 to 6,000 with the highest acreages in the second half of the century; lowland Midlothian 3,000 to 10,000; East Lothian 4,000 to 12,000; lowland Berwick from 1 to 20,300; and lowland Roxburgh 300 to 10,000 acres.¹ In both Berwick and Roxburgh the best period was since 1932 when spring wheat offered an alternative cash crop to the barley-oats pattern which had

1. These figures are interesting in view of recent developments, and the possibility of more domestic wheat being used in bread. A note to this effect is found in Land, L., U.S. and New Type Bread threaten our Wheat Exports, The Financial Post, Toronto, May 4, 1968, where new milling methods in Great Britain were reported and their possibilities assessed. In the Farming Scene, The Scotsman, March 2, 1968, Robert Urquhart noted that imports of hard wheat from abroad were responsible for the expenditure of large amounts when new developments in milling homegrown soft wheat, were about to make possible the use of up to 50 per cent of domestic wheat in bread and biscuit production. Urquhart stated "One alternative crop open to British farmers and this includes Scottish farmers in spite of climatic conditions is wheat."

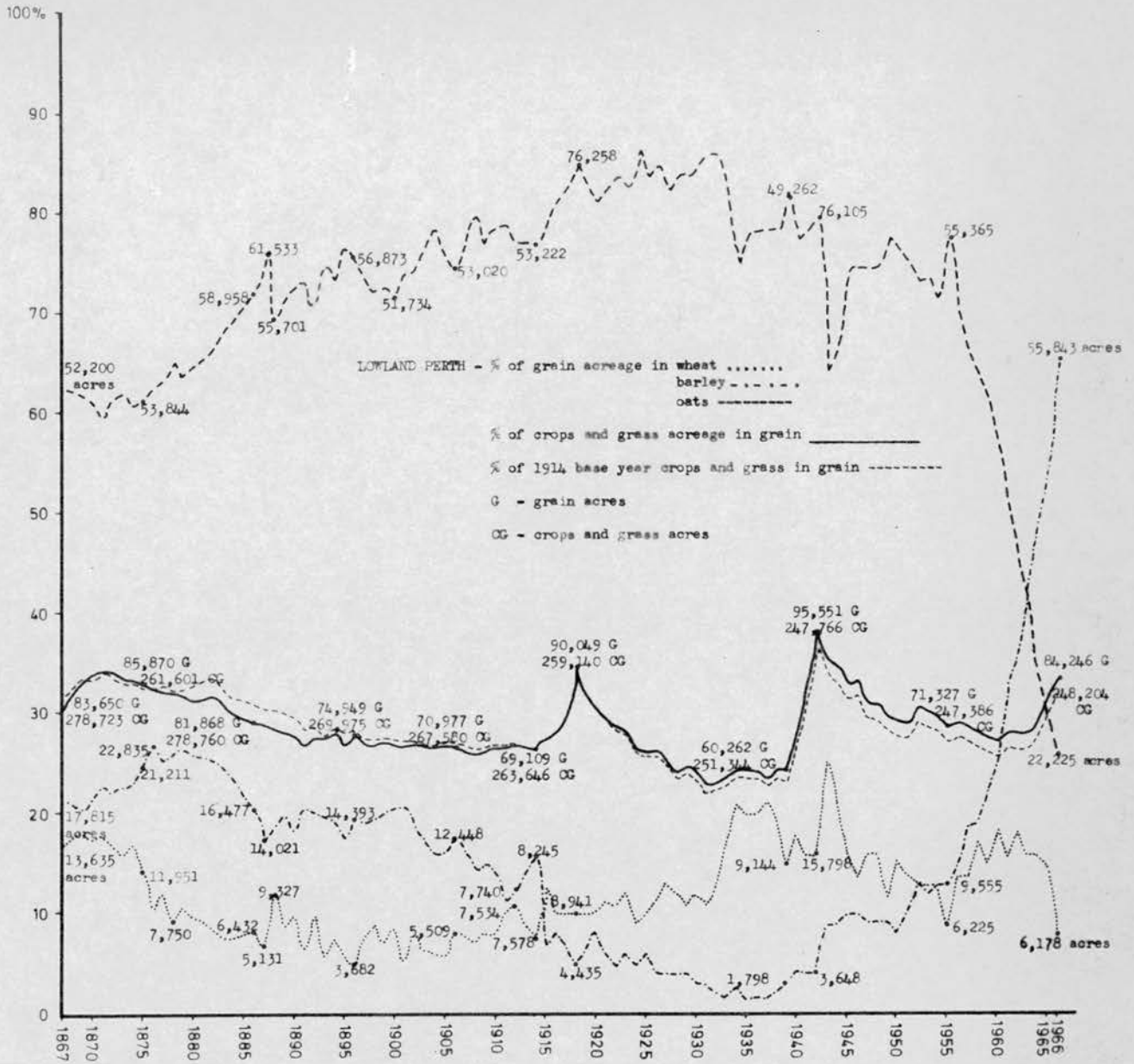


Figure 94

which had prevailed to that time. The lowest acreages have been most often in the last decade of the period to 1966 when barley has taken more of the land previously planted to wheat.

Acreage Number Pattern Maps

The complete year by year percentage position of wheat may be found by divided counties and counties in the grain acreage number pattern maps (Appendix D). A rapid glance at the 54 unit map for any one year will reveal the areas of most importance. In less favourable areas wheat is often shown as a trace, and though this refers to something less the 0.5 per cent of total grain there is some importance in the knowledge that wheat may be grown in part of the area concerned.

Distribution Patterns in Density Shaded Maps

Wheat as a Percentage of Total Grain Acreage Maps

Ten maps are used to represent the fixed situation in average and exceptional years. The 1866 and 1875 maps (Figure 95) are very nearly identical except for small changes which prefaced the great decline in acreage as wheat imports entered the country from the new wheat-lands abroad. The 1896 map (Figure 96) reveals the extent of the decline when wheat tended to be concentrated in the central lowlands. By 1914 the situation was improved with larger areas devoted to wheat and these areas were expanded in 1918 after the favourable provisions offered the growers by the 1917 Corn Production Act. The area under wheat contracted by 1931 but expanded after the

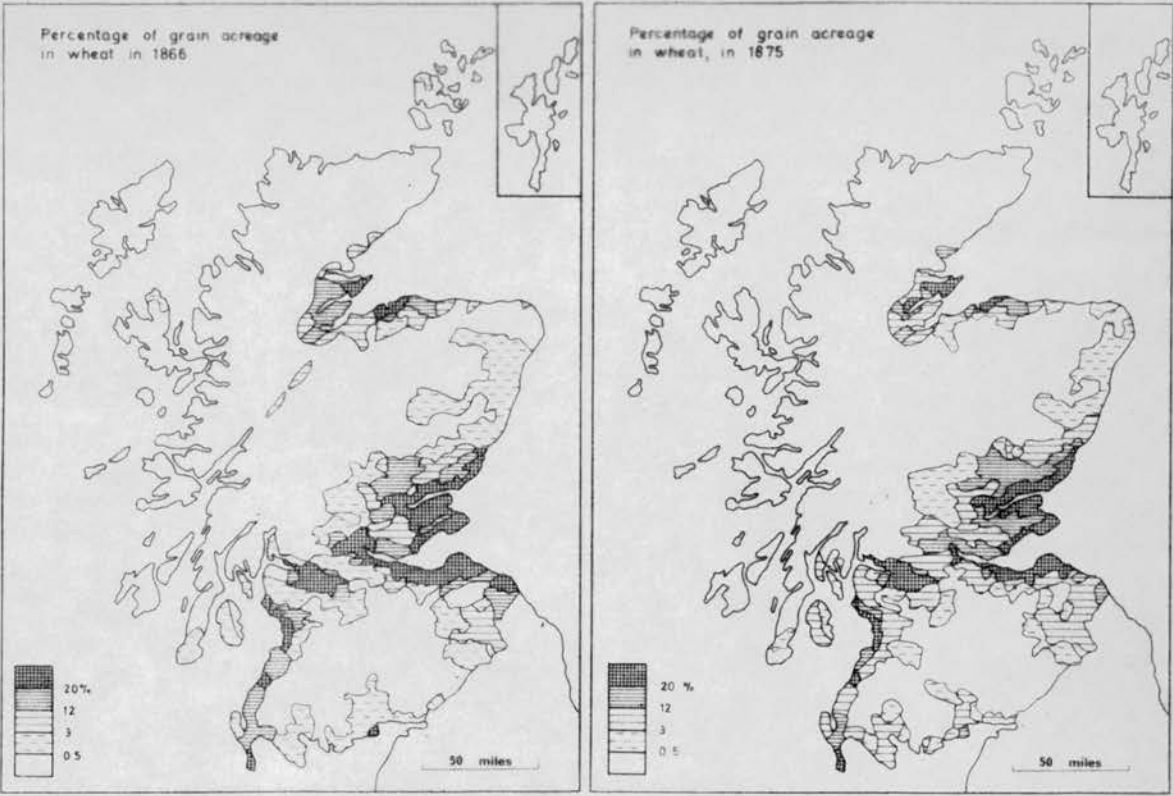


Figure 95

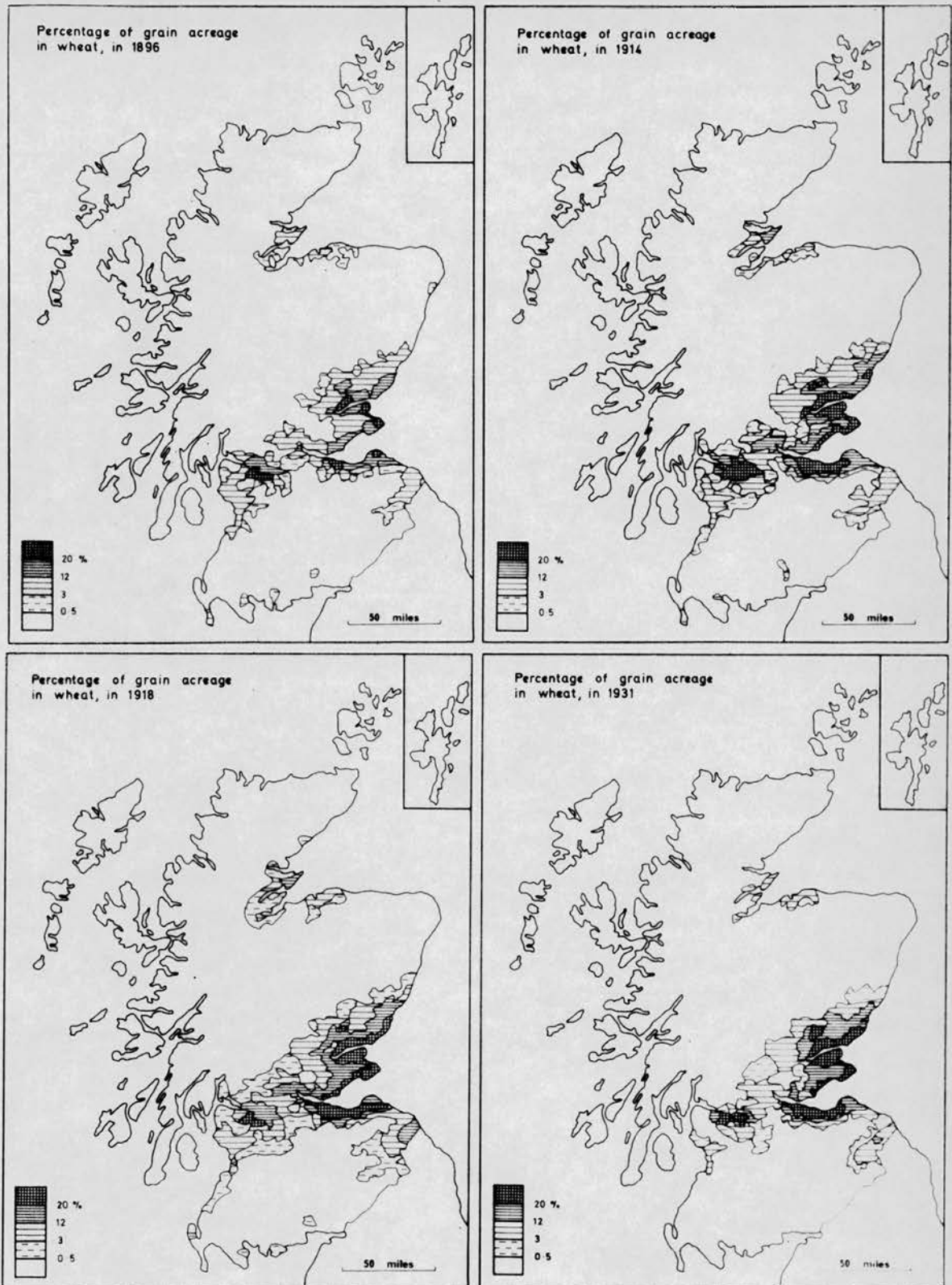


Figure 96

Wheat Act 1932 offered subsidies for the growing of wheat and some of this expansion is notable in the map for 1939 (Figure 97) in northeastern Aberdeen. The 1942 map compares well with the one for 1866 though wheat acreages were not quite as extensive in Aberdeen and Wigtown then. By 1956 some of the traditional wheat ground had been planted to other cash crops such as barley, although wheat acreages were still expanding in Aberdeen and around the Moray Firth where there were few alternative cash crops. In 1966 the map shows a continued shrinking of grain acreages devoted to wheat. In the older traditional wheat areas the key concentration was in East Lothian and neighbouring parts of Midlothian. The maps offer a useful survey of peak, trough and more average years particularly when more than one year may be seen at once on one page. The scales should be noted carefully. Only in the very best arable land around the Firth of Forth did acreages in wheat reach or exceed 30 per cent of the land in grain. Elsewhere the acreages were much smaller.

Wheat Acreage Maps

The real acreage maps (Figure 98) are based on the parishes also. They reveal different patterns because they use a measure consistent over the whole country, while the percentage maps use a measure peculiar to each single parish at a time and these vary greatly in size and amount of land capable of growing grain crops. The years 1931 and 1935 provide patterns before and after the Wheat Act

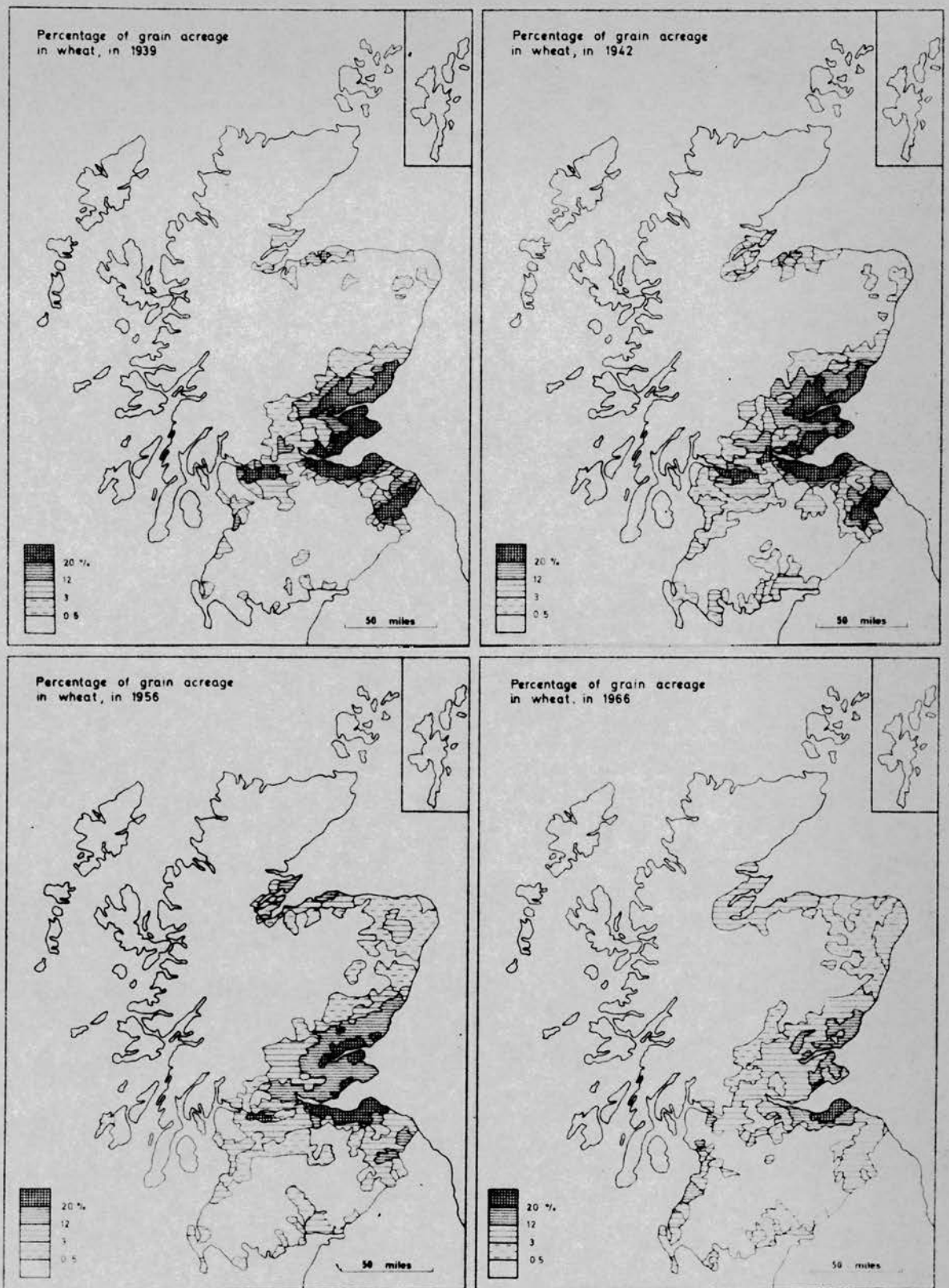


Figure 97

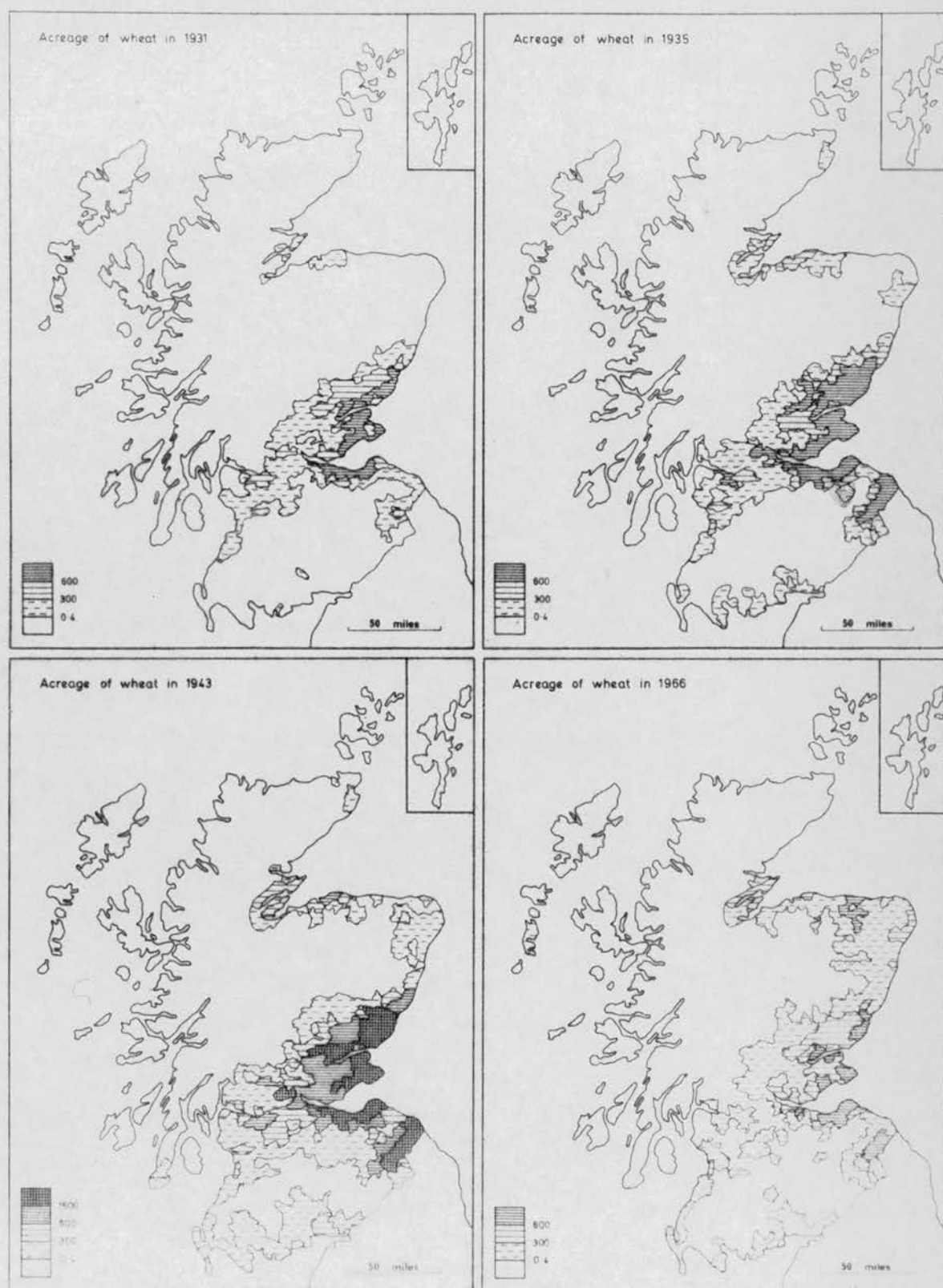


Figure 98

1932 offered relief to domestic grain growers. The year 1943 was a year of high wheat acreages in wartime and 1966 provides the acreage patterns at the end of the hundred years covered. In 1966 part of Banffshire and northern Aberdeen is shown with less than 0.5 per cent of grain acreage in wheat in the percentage map (Figure 97). The actual acreage map for the same year and in almost precisely the same parishes reported quite a significant acreage of wheat, although it was small compared to the other grains grown. This is an illustration serving to emphasize the need for several kinds of density maps to be used simultaneously.

Overall Percentage Change Maps

Four maps offer a sample of percentage change (Figure 99) and present overall connective patterns between some of the fixed percentage maps (Figures 95, 6 and 97). Between 1875 and 1914 the percentage of total grain acreage in wheat was down considerably except in the Firth of Forth and lowland Angus areas. Between 1939 and 1942 there was widespread positive change in the patterns as wheat acreages were increased particularly in lowland Perth. Between 1946 and 1966 the change was more generally negative as wheat acreages dropped although wheat maintained its position in East Lothian and increased in eastern Aberdeen.¹

¹. In a survey of 10 parishes in Aberdeen, George Kay examined patterns of wheat, barley and oats cropping; listed the most common rotations- 6 shift- oats, root crops, oats or barley, and three years ley grass, or 7 shift-oats, barley or oats again, root crops, barley or oats, and 3 years ley grass; and discussed the most favoured grain varieties for the area- Capelle and Koga II wheat were the popular types in 1961. See Kay, G., *Agricultural Patterns and Soil Types in North-East Scotland*, *The Scottish Geographical Magazine* 77(3) December 1961, pp. 131-147.

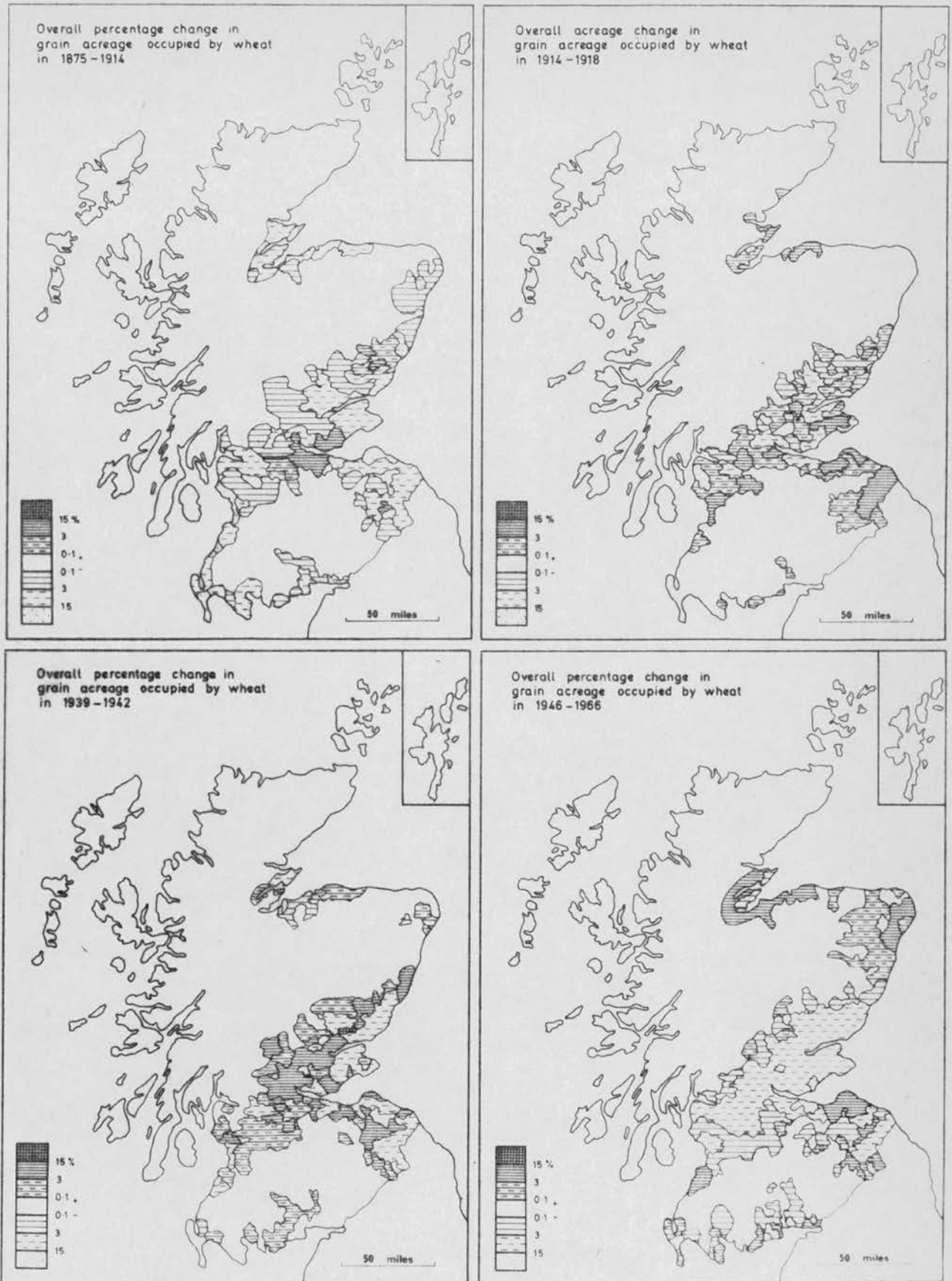


Figure 99

Overall Acreage Change Maps

The actual acreage change shown on these maps (Figure 100) improves the presentation where in large parishes, as in Aberdeen, percentages tended to give an impression of very low acreages because of the wheat relationship to very large acreages of oats and barley. In the overall 1866-1966 map there is much more positive change than would be suspected from the four percentage change maps in Figure 99. On the parish scale changes of as much as two per cent may be related to the grower rotating the crop around the varying sized fields at his disposal, in the usual rotation pattern. Consequently the small acreage changes do not always represent a change in popularity or market.

Ideally these maps should be presented on a more comparable base such as in the unit area method. This device would make the pattern more consistent areally and remove most of the isolated broken block pattern of parishes from the 1866 to 1966 map. Overall acreage change maps were not prepared for all parts of the century and the last two give an impression of the post-1945 pattern. The extent of the changes is nowhere very large.

Equal Area Bar Graph Sections and Section Maps

The relative position of wheat is readily shown in the section graphs for 1866, 1942 and 1966 (Figures 76-81 on pages 186-191). The concentration in the Lothians and the Merse of Berwick is most striking. The section maps for 1966 add a spatial dimension (Figures 84 a, b and c, on pages 196-198) and make possible the examination of the relative size of wheat acreages over a wide area.

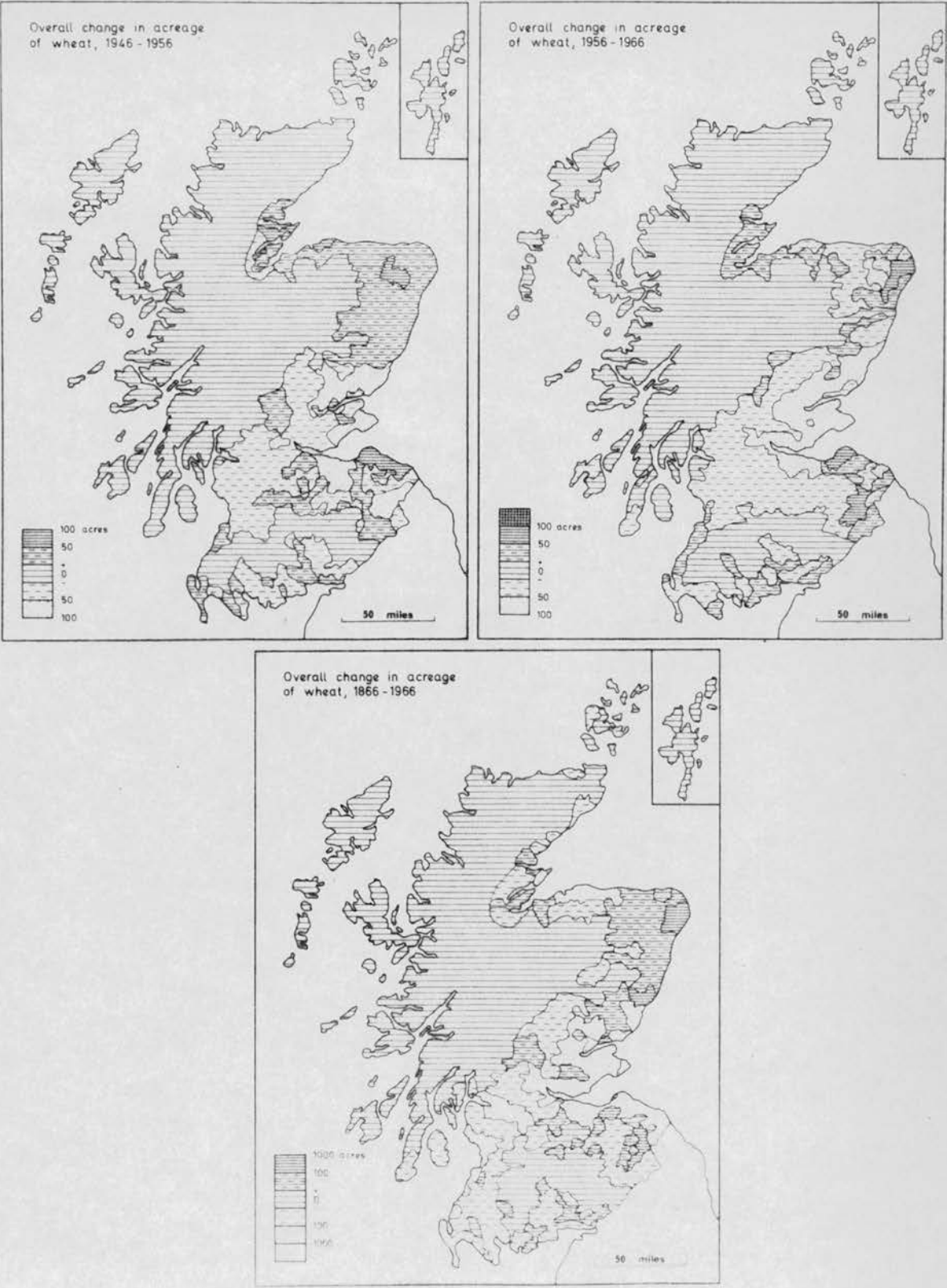


Figure 100

Regionally Based Bar Graph Map

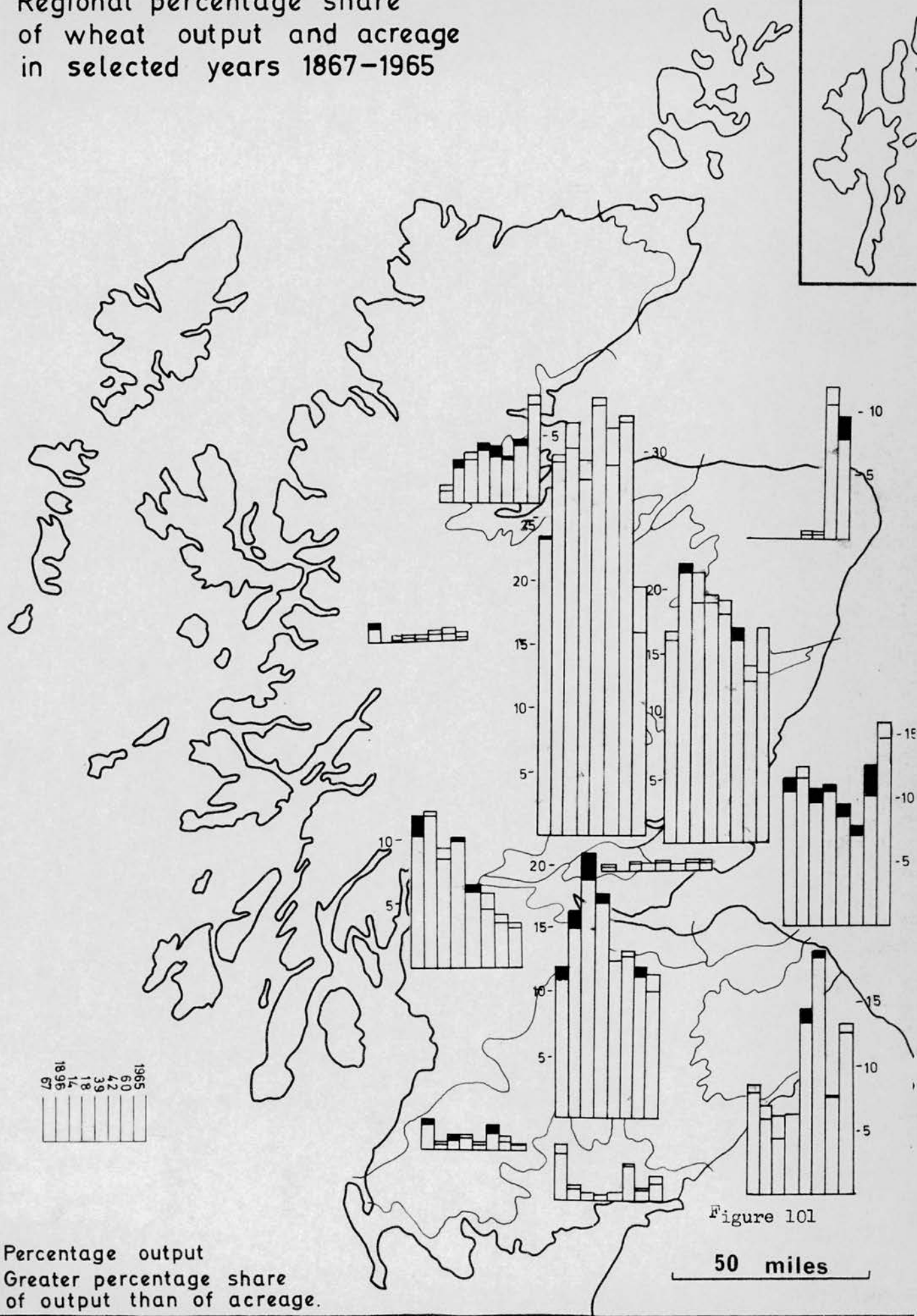
This map (Figure 101) shows at one glance the position of wheat over the country by grain regions in the years 1867, 1896, 1914, 1918, 1939, 1942, 1960 and 1965. If space was available on one map for the whole country, the presentation would have been improved on the 54 unit divided county and county base. Nevertheless, the changes through time are clearly shown in a selection of peak, trough and other years and the comparative qualities of the graphs are good by regions.

Grain Order of Rank Maps and Graphs

Wheat did not play a commanding role in the order of grain grown until 1943 during the war and a smaller but more widespread scale recently, in 1966 when the position of wheat in the order changed. Many areas where the order of grain by acreage had been barley then oats then wheat (BOW) showed a change to patterns barley, wheat, oats (BWO) or even wheat, barley, oats (WBO) and wheat, oats, barley (WOB). The latter orders as far as wheat is concerned may be considered high orders and land which can support such orders must be highly arable and favourably located. Changes in rank order are most clearly shown in the 6 graphs from 1916-1966 (Figures 102, 103, and 104). The positive effect of the subsidies offered in the Wheat Act 1932 is striking in the graphs. The ranking was done for the entire century 1866-1966 but the graphs were done for the most active change period which was in the second half.

Spring wheat made possible the swing to wheat evident in Berwick and Roxburgh after 1932. About 550 acres of spring wheat was grown in lowland Berwick in 1916 and 100 acres in

Regional percentage share
of wheat output and acreage
in selected years 1867-1965



Number of parishes involved in grain order of rank changes, 1916-1966

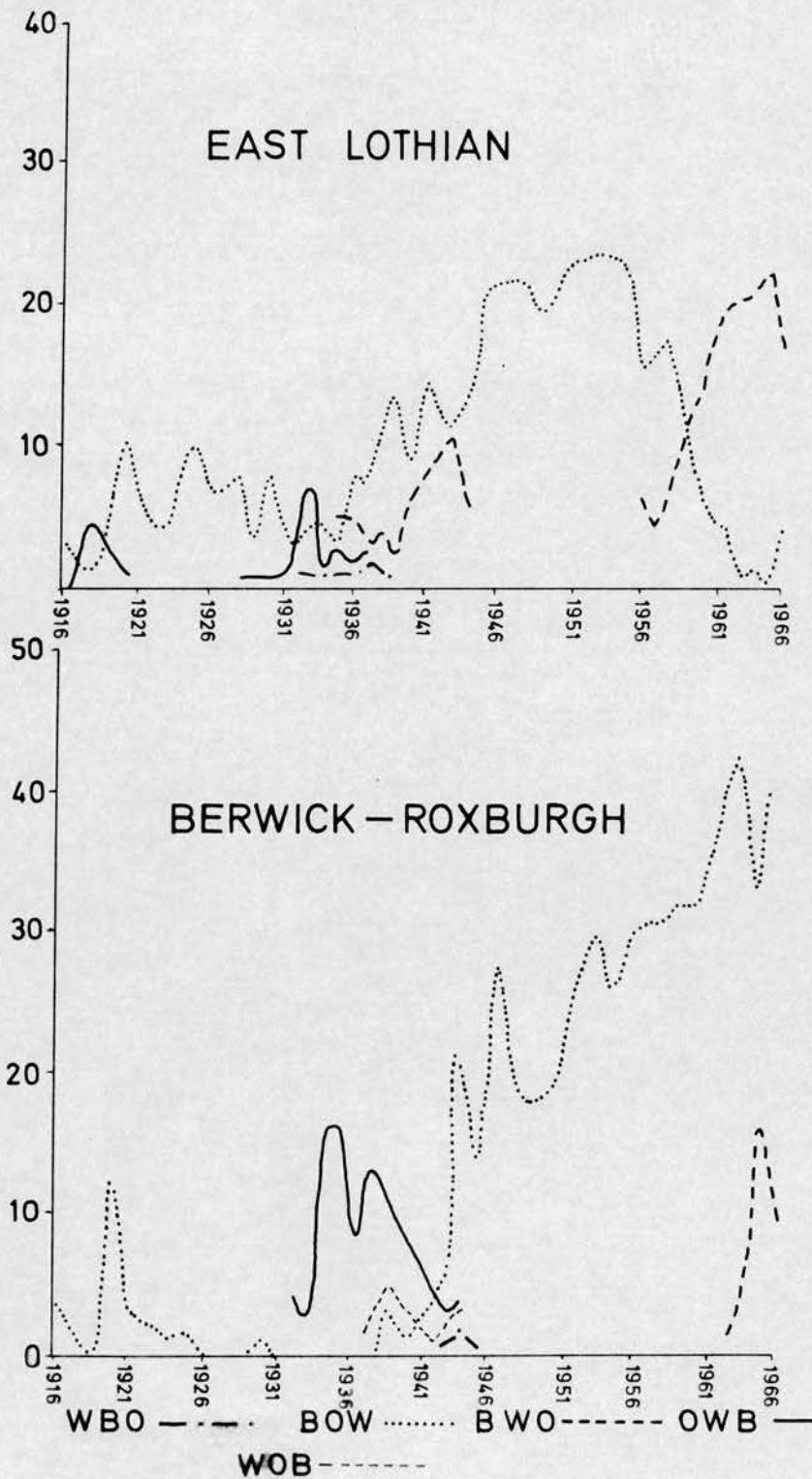


Figure 102

The longterm older OBW, OB, O, patterns are omitted

Number of parishes involved in grain order of rank changes, 1916-1966

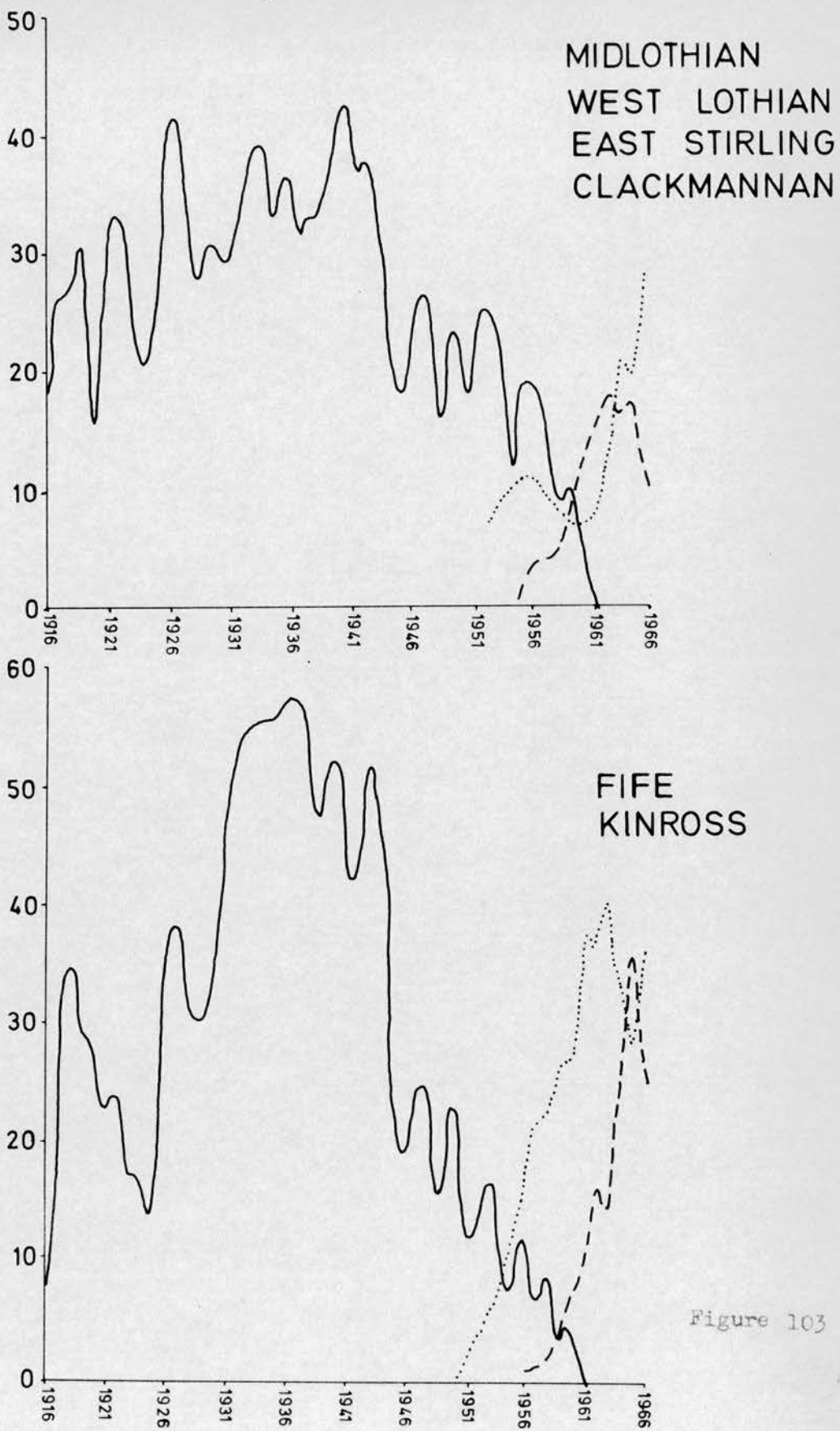


Figure 103

The longterm, older OBW, OB, O patterns are omitted
BOW BWO - - OWB —

Number of parishes involved in grain order of rank changes, 1916-1966

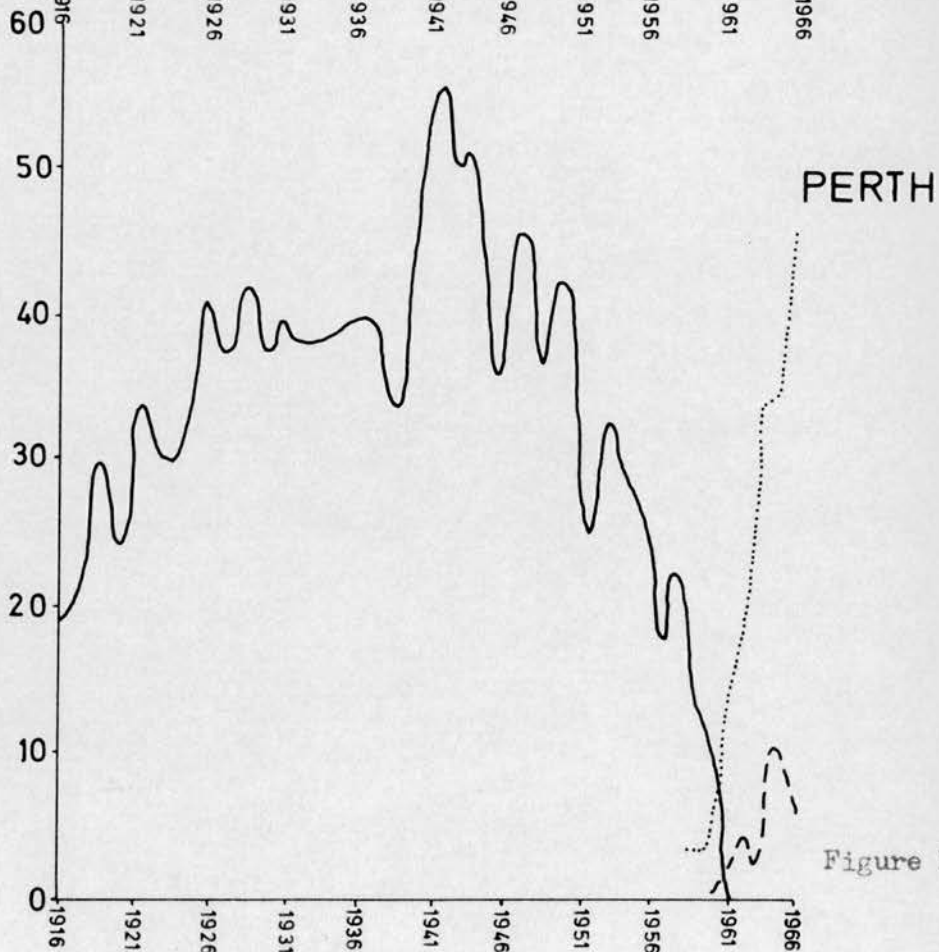
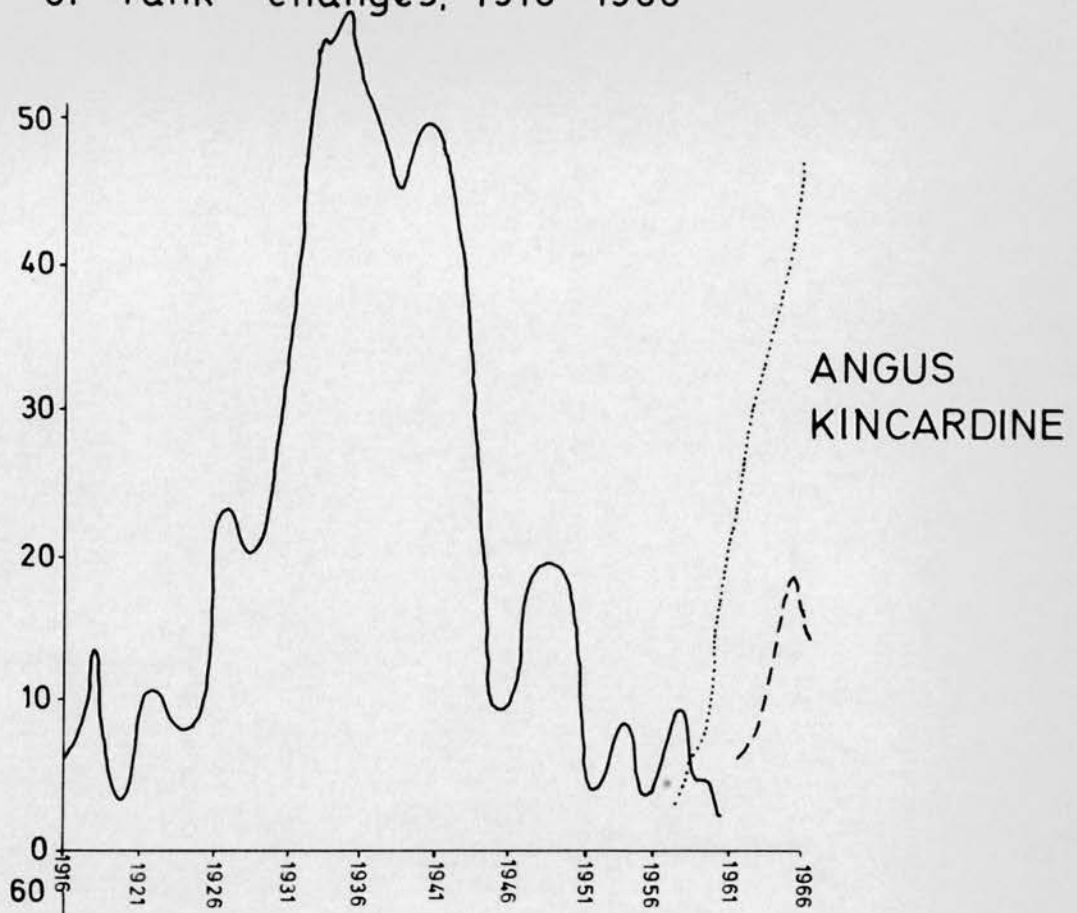


Figure 104.

The longterm older OBW, OB, O patterns are omitted

BOW..... BWO—— OBW —

Roxburgh. After the Wheat Act 1932, Berwick reported over 1,100 acres in 1933 and Roxburgh 550. By 1936, Berwick had over 3,000 acres and Roxburgh half that amount. Spring wheat continued to be important until 1952, the last year when it was reported as a separate category and in that year more than 1,500 acres was grown in Berwick and 1,100 in Roxburgh. In other areas, spring wheat exceeded 1,000 acres in Angus in 1936, 1939 and 1945, in Dumfries in 1943, Fife in 1936 and 1939, Midlothian in 1943, 1944 and 1945, and East Lothian in 1945. Spring wheat was most popular in the eastern coastal lowlands from Kincardine south, between the years 1915 and 1946, except for Berwick and Roxburgh. In many areas the growing of spring wheat served to re-popularize wheat as a crop. In 1945 spring wheat was grown in about 1,100 acres along with 31,000 acres of winter wheat in Angus. This and other approximate relationships are shown in the following table of rough totals:

| 1945 Acreage | County | Spring Wheat | Winter Wheat |
|--------------|-----------------|--------------|--------------|
| | Angus | 1,100 | 31,000 |
| | Berwick | 5,100 | 3,100 |
| | Dumfries | 250 | 900 |
| | East Lothian | 2,400 | 12,700 |
| | Kirkcudbright | 250 | 300 |
| | Midlothian | 1,200 | 5,300 |
| | Perth | 700 | 11,500 |
| | Ross & Cromarty | 450 | 700 |
| | Roxburgh | 2,700 | 3,000 |
| | Stirling | 200 | 1,900 |
| | West Lothian | 300 | 2,400 |

Although the acreages of total wheat are not very large in Dumfries or Kirkcudbright in the southwest or Ross and Cromarty in the Moray Firth area, the relationship of spring to winter wheat is significant for those regions. If weather was not suitable for a winter sown crop then a second opportunity was possible in the spring.

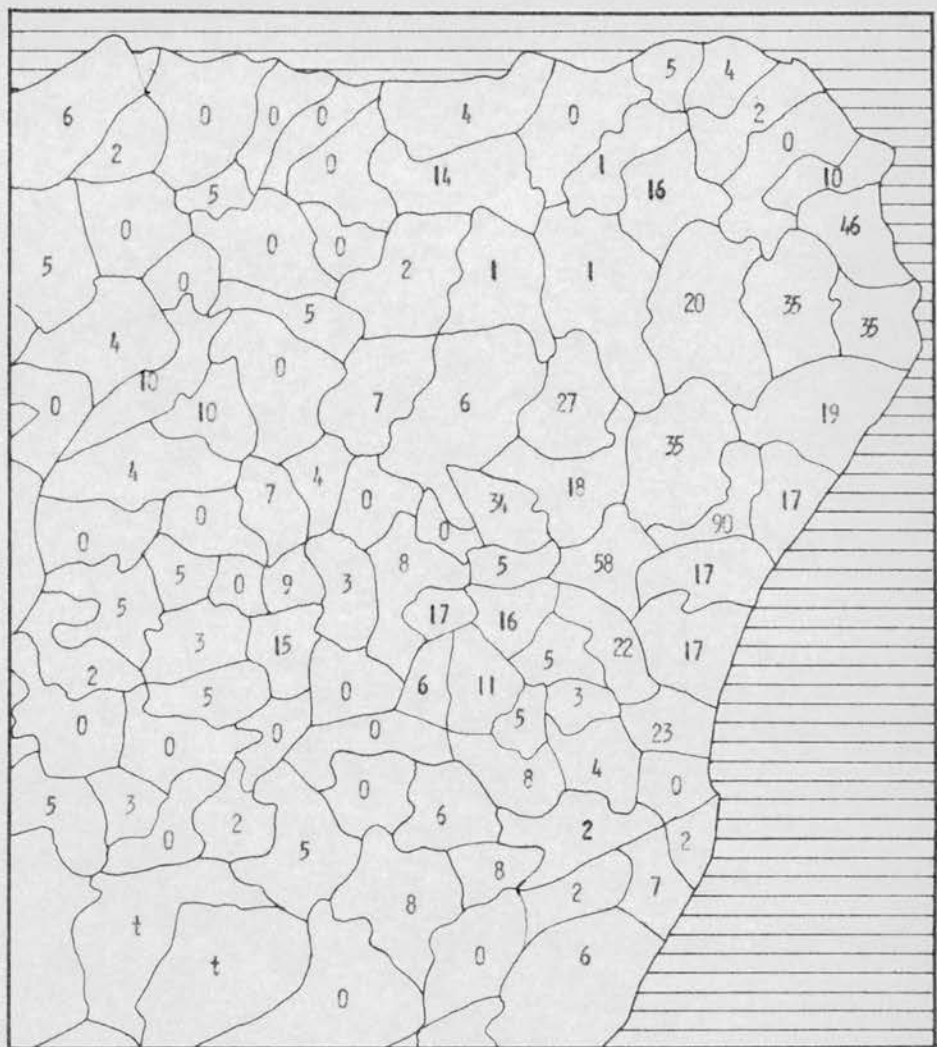
Raised Statistical Surface Maps

The acreage position of wheat is shown also in the two raised statistical surface maps which deal with the divided county and county acreages in 1866 and 1966 (Figures 86 and 87 on pages 203 and 204). The greatest difference is the expansion of barley in 1966 into land devoted to wheat earlier. In arable lowland Aberdeen wheat acreages were large enough in 1966 to be easily mapped at this scale while in 1866 they were not.

Unit Area Wheat Acreage Stepped Frequency Surface Diagrams

The location of the most important wheat areas is clearly shown in both diagrams (Figures 105 and 106). The one of lowland Aberdeen was drawn to a very large scale with one millimetre of vertical height representing two acres. This scale was chosen as part of the experimental approach since it seemed necessary to show the smaller unit area acreages in the western and southern parishes. The concentration of wheat in New Machar, Logie-Buchan, Udney, Ellon, Old Deer, Longside, St. Fergus and Peterhead is clearly shown with the highest per unit area acreage being found in Udney and Logie-Buchan.

In the other diagram a most satisfactory division into two parts reveals physiographic controls which limit the extent of wheat growing in the area. The larger traditional wheat area is north of the Moorfoot and Lammermuir Hills and bounded in the northwestern section by the Pentland Hills. This confinement to Midlothian and East Lothian has been notable through all of the maps. The Merse of Berwick and



1 unit = 5 mm² or 14.7 sq. Kms

(1:625000)

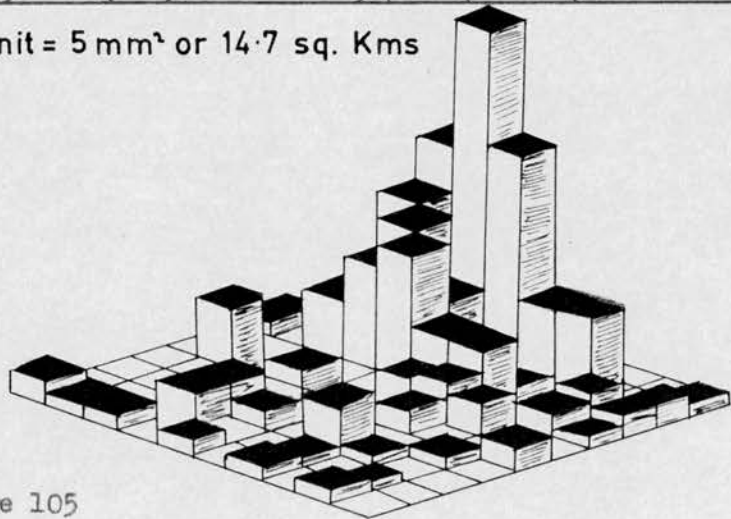
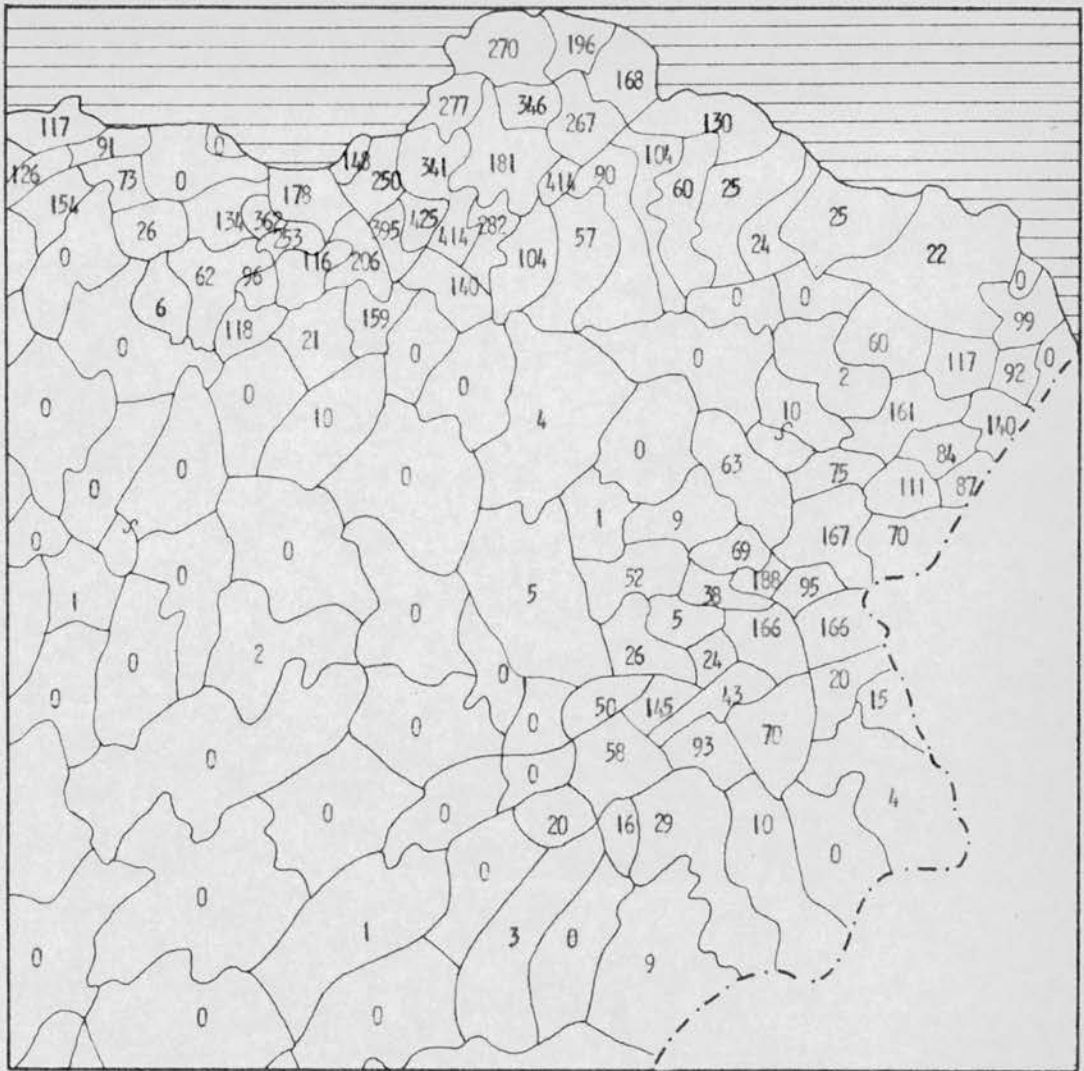


Figure 105

Vertical scale- 1mm. : 2 acres

Acreage of wheat per unit area in 1966



1 unit = 5mm² or 14.7 sq.Kms

(1:625000)

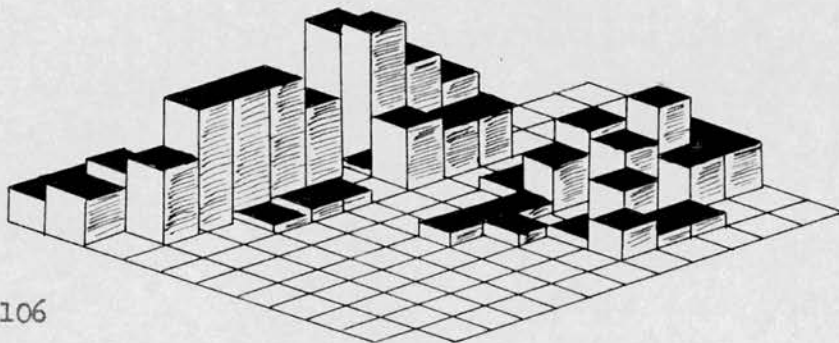


Figure 106

Vertical scale- 1mm. : 25 acres

Acreage of wheat per unit area in 1966

extensions into lowland Roxburgh are revealed with little or no acreages in the hills on three sides. The scale used for the second stepped frequency surface offers a more realistic and less extreme pattern compared to the first. The numbers in the key maps supply a good comparable base for density shading or isoline mapping.

The Changing Pattern of Barley Distribution

The barley patterns¹ are the most extreme in their fluctuations and the recent demonstration of ability to grow barley as a very high class feed grain has answered an international market demand. The strongest factors in increasing barley acreage has been the outstanding improvement in varieties which among other developments over the years has included smooth awned types and higher yielding hybrids as well as the strong demand for the output. Now that little or no land need be kept to provide oats for horses some can be planted to a cash grain crop which is adaptable to varied conditions. As a surplus crop on the farm, barley may be used for all the usual livestock and the remainder sold. In the past, over-expansion of barley growing led to spectacular cutbacks in the crop in the United States, especially in the dry areas of the Dakotas, during the disastrous drought of 1931-1937.² In Scotland and Great

1. Britton, D. K., The Increase in Barley Growing and its Regional Pattern, Report to the School of Agriculture, University of Nottingham, 1961 pp68-74.

2. In 1931 1,844,000 acres of barley were sown but never harvested. See pages 70 and 73 in Weaver, J. C., Barley in the United States, A Historical Sketch, The Geographical Review 33 (1943) pp. 56-73.

Britain in general there have been gloomy forebodings in the past few years about a possible over-extension of barley and an imminent glut on the market.¹ On the opposite side the distillers of Scotland, key producers of excise duty, enjoying an outstandingly expanded export trade, have developed a new mashing process capable of raising their output by 30 per cent and dependent on home-grown malting barley.² The newer varieties of barley recommended in 1967 included four rated as good malting quality; Zephyr, Cambrinus, Mentor and Maris Baldric, with Ymer now not so favoured as the more recently developed and tested varieties.³ The variety Golden Promise was added to the list in 1968 and Cambrinus and Mentor did not appear.⁴

The nucleus for Scotland's considerable expansion into barley cropping was already established in 1866 in eastern Fife and East Lothian in the parishes of St. Monans and Dunbar.

¹ See an item in the Scotsman, December 31, 1966 concerning a warning attributed to the Home-Grown Cereals Authority, pointing to a climb from 2.8 to 8.8 million tons of barley in ten years in Great Britain, stating "there is a clear possibility of an imbalance arising between the demand for barley and its supply," and called for a switch to wheat.

Also an item in The Times, July 30, 1967 by Woodland, J., which again referred to the Home-Grown Cereals Authority call for wheat in the place of barley where Woodland said "This in spite of the buoyant export market for barley which has helped considerably in the past two years to dispose of record crops" while he attributed to the H-G.C.A. the statement "grow more wheat in place of barley, . . . It has a much greater potential than home-grown barley as a competitor for foreign grain." Experiences with wheat from 1875 to 1966 have not borne out this latter claim. However the possibilities for using more domestic wheat in the nation's bread and biscuits and cutting imports of hard wheat auger well for British wheat growers.

² The Industrial Correspondent, The Scotsman, August 18, 1967, discussing Tomatin Distillers Co., Ltd., the largest malt distillery in Scotland, near Inverness.

³ Edinburgh and East of Scotland, College of Agriculture, Cereal Variety Recommendations 1967, a leaflet prepared in November 1966

⁴ The recommendations for 1968 from the same source as in note 3

From these parishes the popularity of barley growing spread out into the surrounding parishes and counties. The areas under barley decreased generally from 1921-1941 but expanded rapidly after 1955 around the Forth region and from 1960 elsewhere. By 1966 all of Scotland's best arable lowland south of Caithness had substantial acreages of barley. The slump after 1921 was partly the result of government intervention in the Corn Production Act 1917 which offered acreage support to stimulate wheat and oats growing but excluded barley.

Line Graphs

The history of barley growing is revealed very starkly in the divided county and county graphs over the century (Figure 107 and 108). Most of the lowland parts of counties recorded their lowest acreages in the period 1921-1941 with some having low points recorded in 1917 and 1918 as well. Interestingly enough, the counties which appeared to be the most sensitive to the Corn Production Act 1917 were in the Moray Firth area in the lowland parts of Inverness and Moray key producers of malting barley for local distilleries and in Kincardine where barley acreages were down and oats up.

From 1866-1966 the lowland parts of counties with the barley production were: Moray with 3,500 to 20,000 acres and usually over 8,000 acres; Ross and Cromarty 1,000 to 23,000 generally over 5,000; Banff with 4,000 to 25,000 generally over 6,000; Aberdeen 4,100 to 119,600 but generally over 10,000 acres; Angus 500 to 65,000 generally over 10,000; Kincardine 3,000 to 26,000 generally over 7,000; Perth 1,500 to 56,000 but

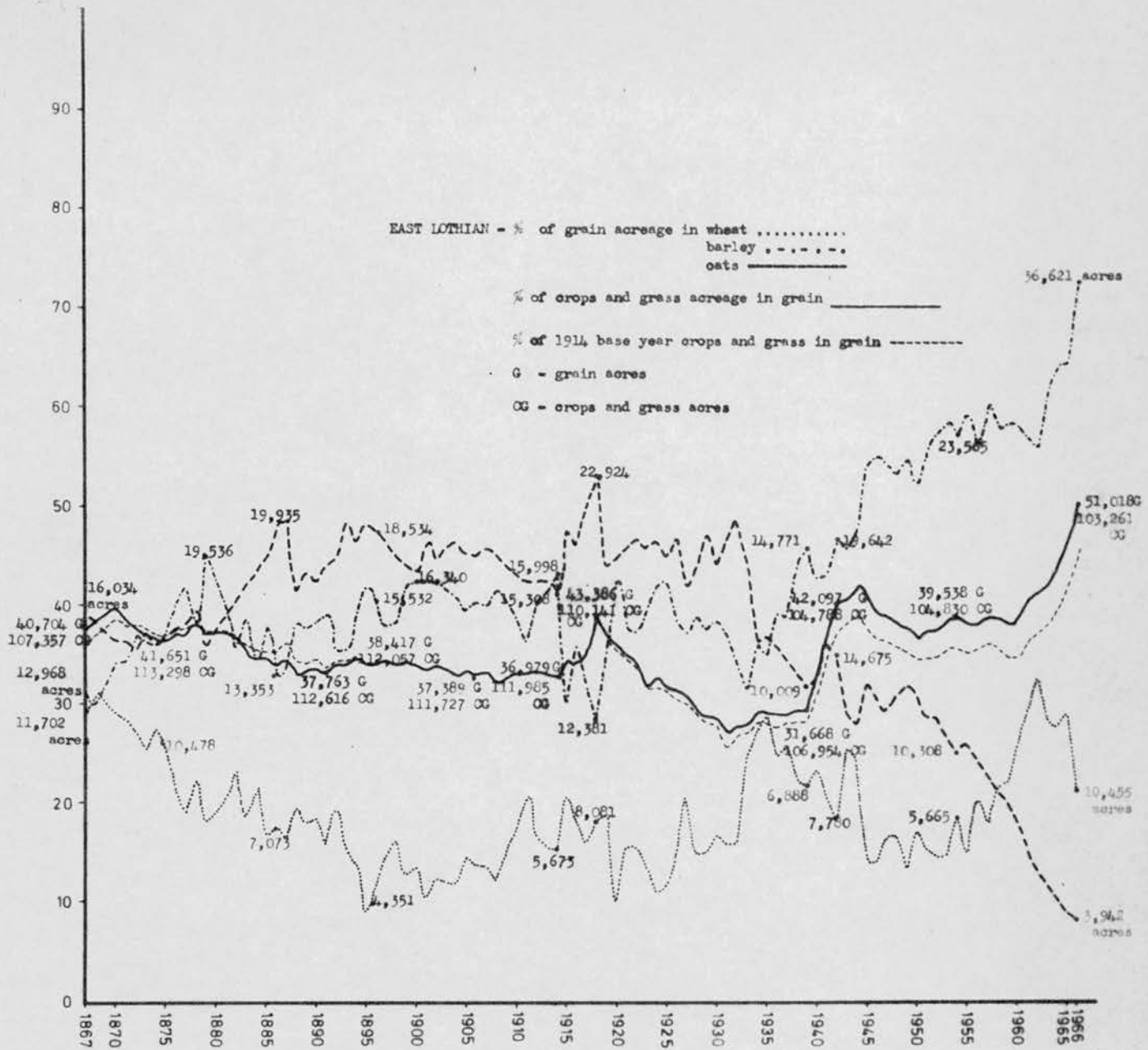


Figure 107

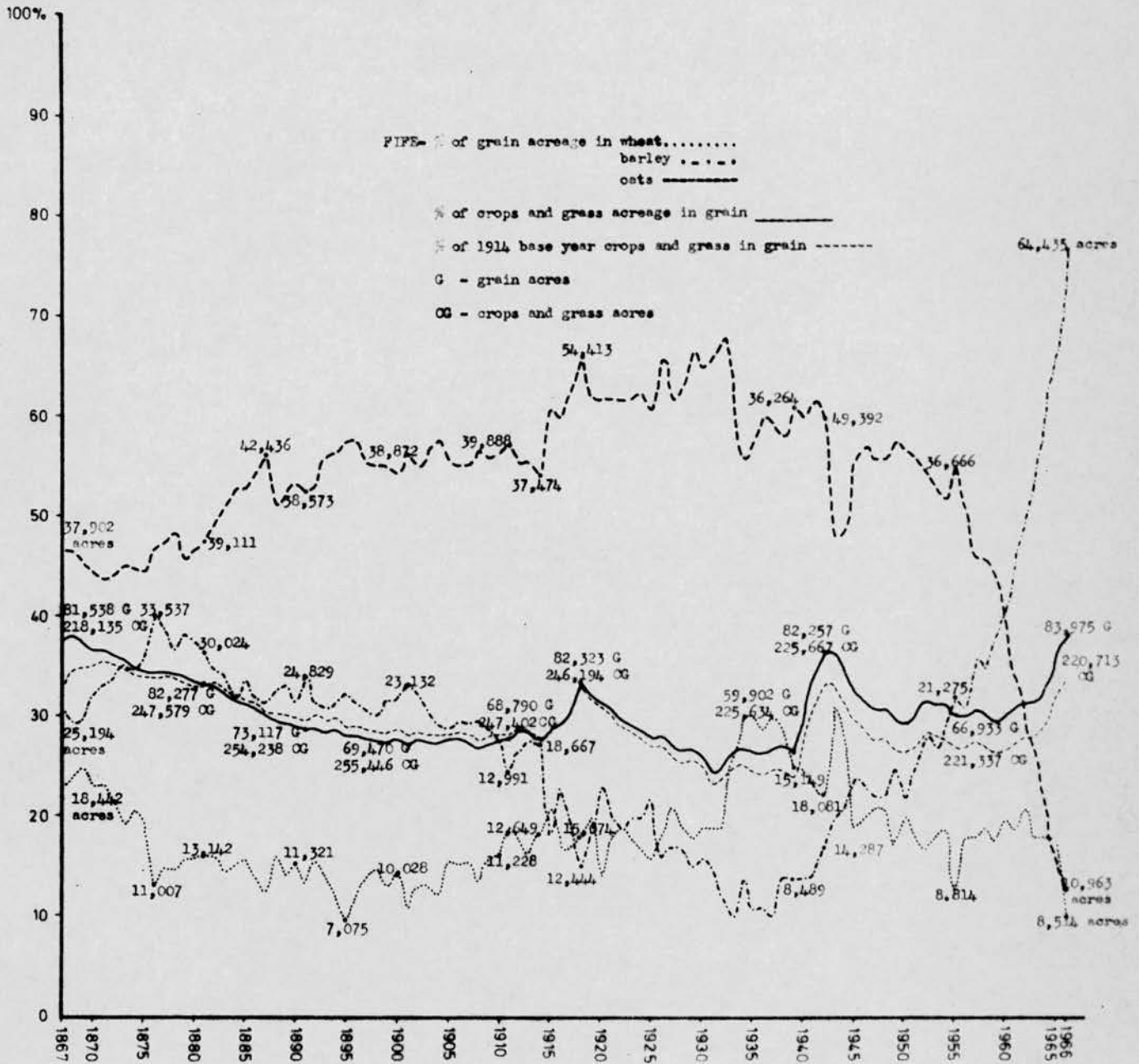


Figure 108

generally over 4,000; Fife 7,000 to 64,000 generally over 10,000; East Lothian 12,000 to 36,500; Berwick 7,000 to 50,000 generally over 15,000; Roxburgh 5,000 to 31,000 generally over 10,000; Midlothian 2,000 to 17,000 but generally over 4,000; and West Lothian 1,000 to 13,000 generally over 2,000 acres. The two graphs for East Lothian and Fife illustrate the patterns in two confirmed barley growing counties.

In the west and southwest, barley has been of little importance with scarcely more than a trace recorded over the century until very recently. Since 1955, there have been noteworthy expansions from a few acres to 19,000 in 1966 in lowland Dumfries, to 9,700 acres in lowland Kirkcudbright, to 13,800 in lowland Wigtown, to 2,200 in lowland Ayr, to 4,500 in lowland Lanark, to 7,200 in upland Lanark, to 2,300 in Peebles, to 4,200 in Renfrew and to 1,500 acres in lowland Dunbarton.

The only divided county recording a consistent decrease in barley acreage over the century was upland Inverness. In that large area, barley acreages in 1866 of 4,700 acres declined to less than 600 acres in 1966 with the lowest period following 1921.

Acreage Number Pattern Maps

The grain acreage number pattern maps (Appendix D) offer the complete story by 54 units by single years. The spread of barley growing may be followed from 1956 to 1966 when the largest increases in acreages were recorded. Where the percentage assigned to barley seems small as compared to oats, as in Aberdeen, perspective may be maintained by converting the percentage to real acres from the crops and grass base.

Distribution Patterns in Density Shaded Maps

Barley as a Percentage of Total Grain Acreage Maps

Ten maps based on a parishes represent fairly normal as well as exceptional years from 1866-1966. The maps for 1866, 1875, 1896 and 1914 (Figure 109) do not vary considerably in pattern. The 5 per cent or less class is most variable but it may refer to very small acreages in the southwest and western highlands. The importance of lowland Berwick and Roxburgh is seen in 1875 and 1896 and East Lothian in 1896 and 1914 with strong concentrations in Moray and the Outer Hebrides. The percentage acreage of barley contracts and the scale of barley growing diminishes generally by 1918 and in the years 1931 and 1939 (Figure 110), except in East Lothian in the latter year. Expansion is notable in 1942, mainly in the lowest scale class of 5 per cent or less. The 1956 map (Figure 111) shows a moderate increase in barley acreage, offering just a hint of the changes to come. The final 1966 map shows widespread areas with over 60 per cent of grain acreage in barley, extending north into Sutherland and to the southwestern tip of Wigtown. The details are best seen in the maps themselves. The distortions offered by different base reference maps with barley as the example may be seen in the methodology section (Figures 1 and 2 page 26f.).

Barley Acreage Maps

The real acreage maps for 1944, 1950, 1955 and 1966 (Figure 112) give barley a better representation than the percentage maps before 1966. The ones chosen illustrate years of large acreage in 1944 and low acreages in 1950 and 1955

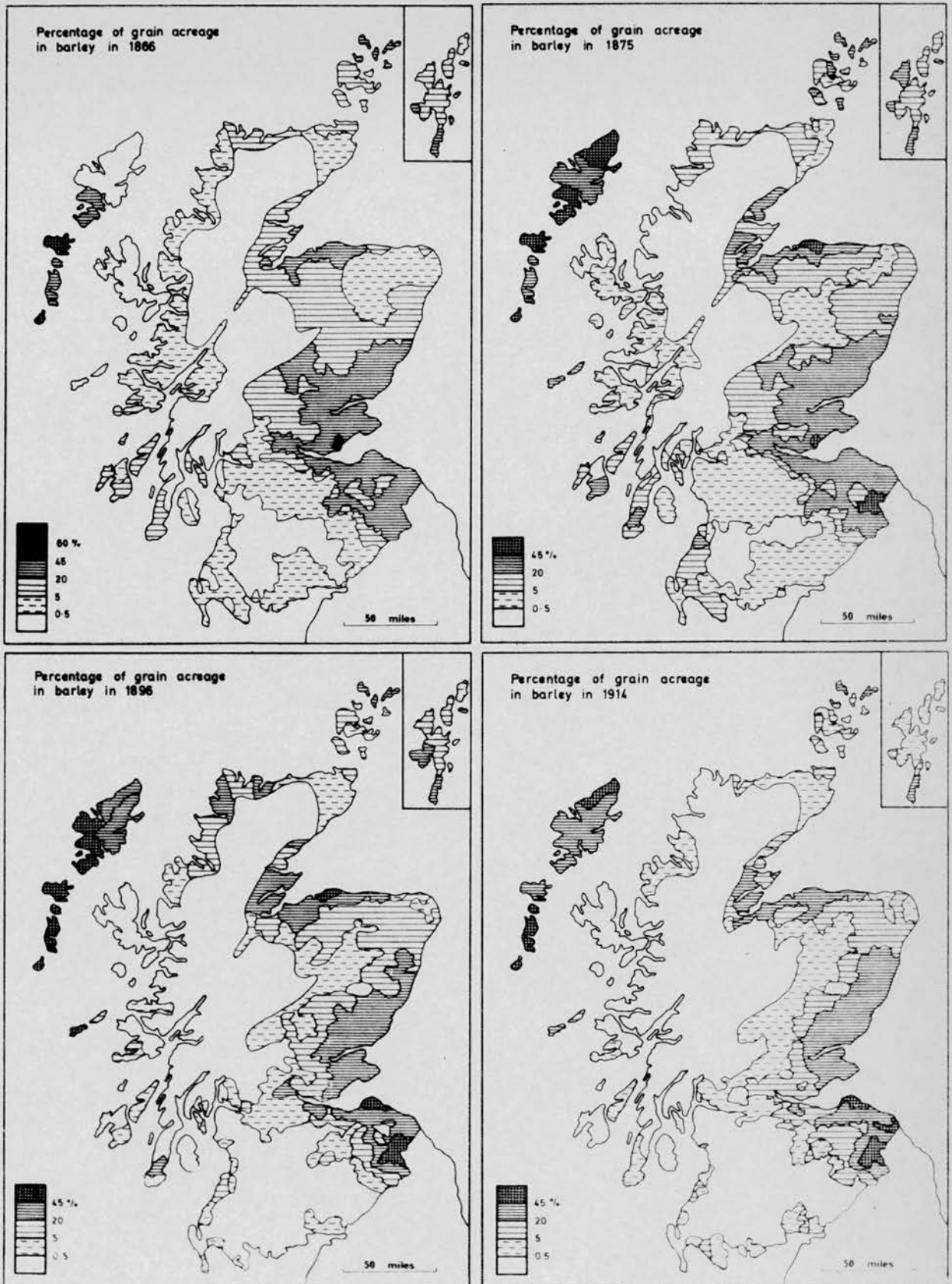


Figure 109

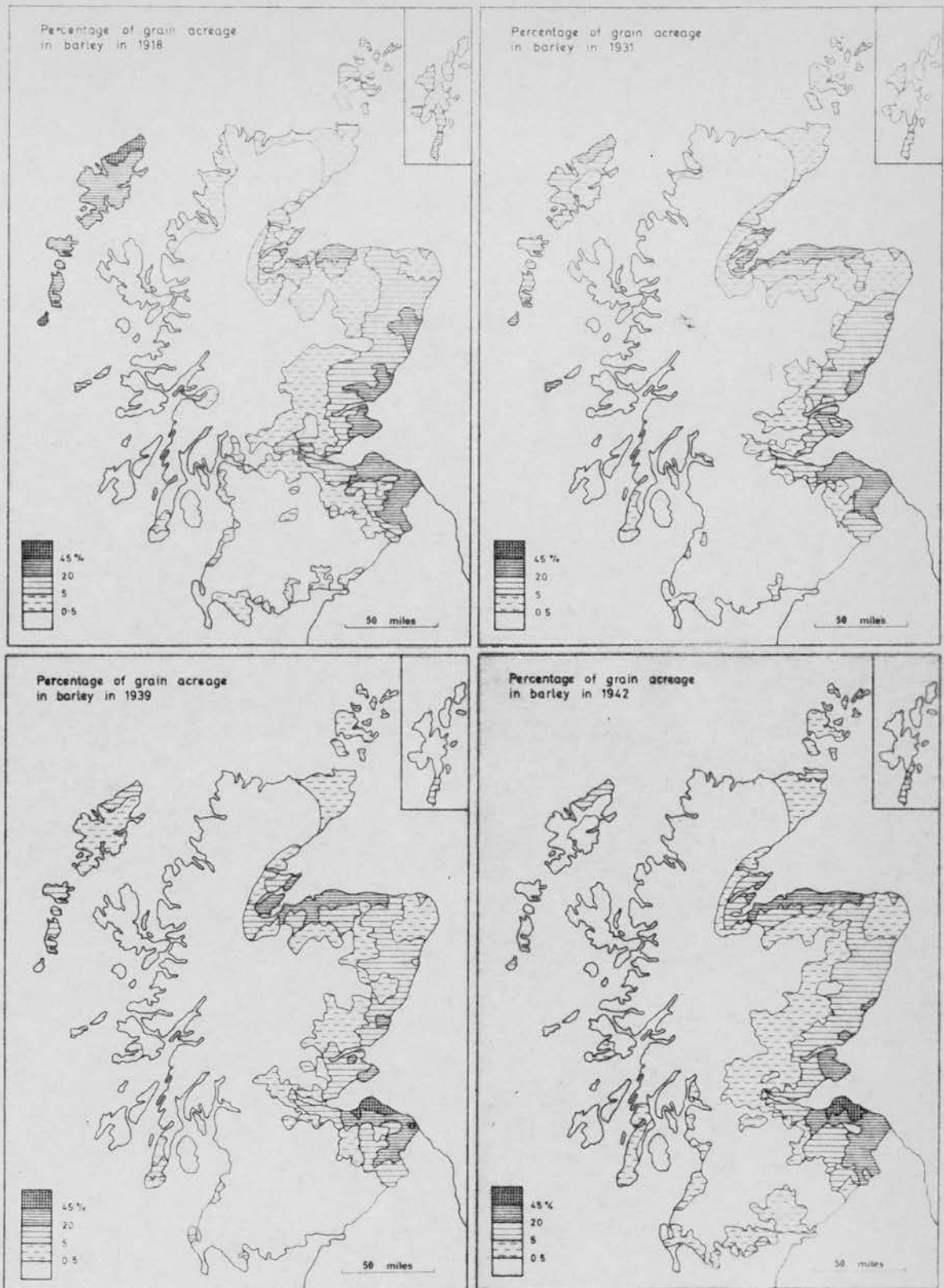


Figure 110

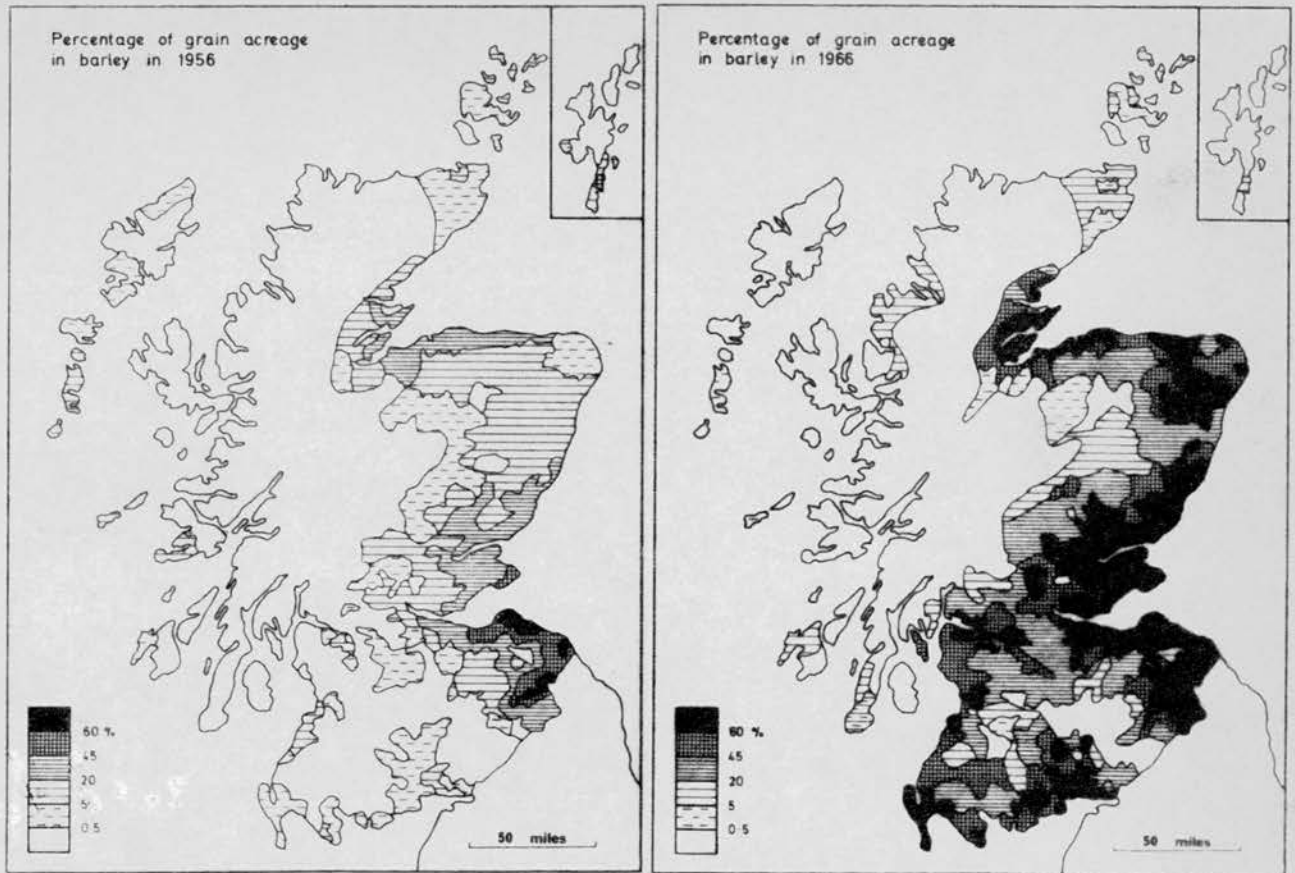


Figure 111

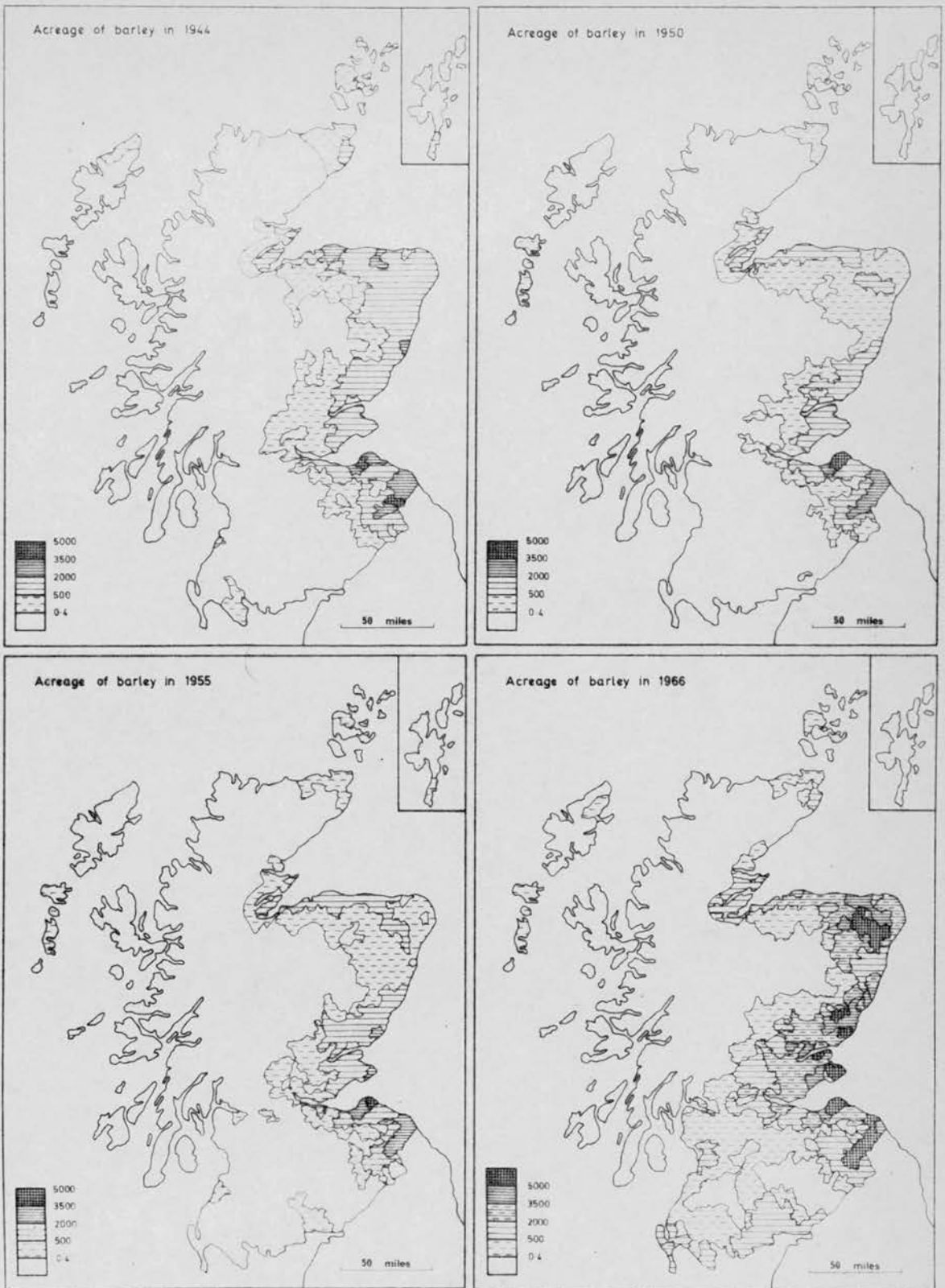


Figure 112

changing to very large acreages in 1966. The actual acreage maps offer a different emphasis and are presented for their comparative value to the percentage based maps in Figures 109-111.

Overall Percentage Change Maps

The 1875 to 1914 (Figure 113) percentage change map shows a widespread negative or decreasing acreage pattern but it is generally of a light nature except in Midlothian, Stirling, Fife and Perth. The positive swings are in Kincardine, Aberdeen and Banff and in East Lothian, Berwick and Roxburgh. The 1914-1918 map is almost entirely negative since the Corn Production Act 1917 did not support barley growing and it is in contrast to the one for 1939-1942 which is mostly positive as acreages increased but not strongly so. The real change is apparent in 1946-1966 with large expansion of barley acreage in most of the better arable areas and in a great many parishes less well favoured. The 1946-1966 map hides the fact that the increase in popularity of barley took place after 1955 in the Forth Area and generally after 1960 elsewhere. This map is a very good illustration of misleading patterns when the period chosen for coverage is too broad. A more accurate perspective may be gained by noting the 1956 and then the 1966 patterns in the fixed percentage maps. It may be compared also with the acreage change map 1946-1956 which follows. The change maps were prepared after a study of the patterns offered by the line graphs. In most cases peaks and troughs occurred in the same years throughout the country, but other years were chosen for comparison on an experimental basis to show where a poor selection can be misleading.

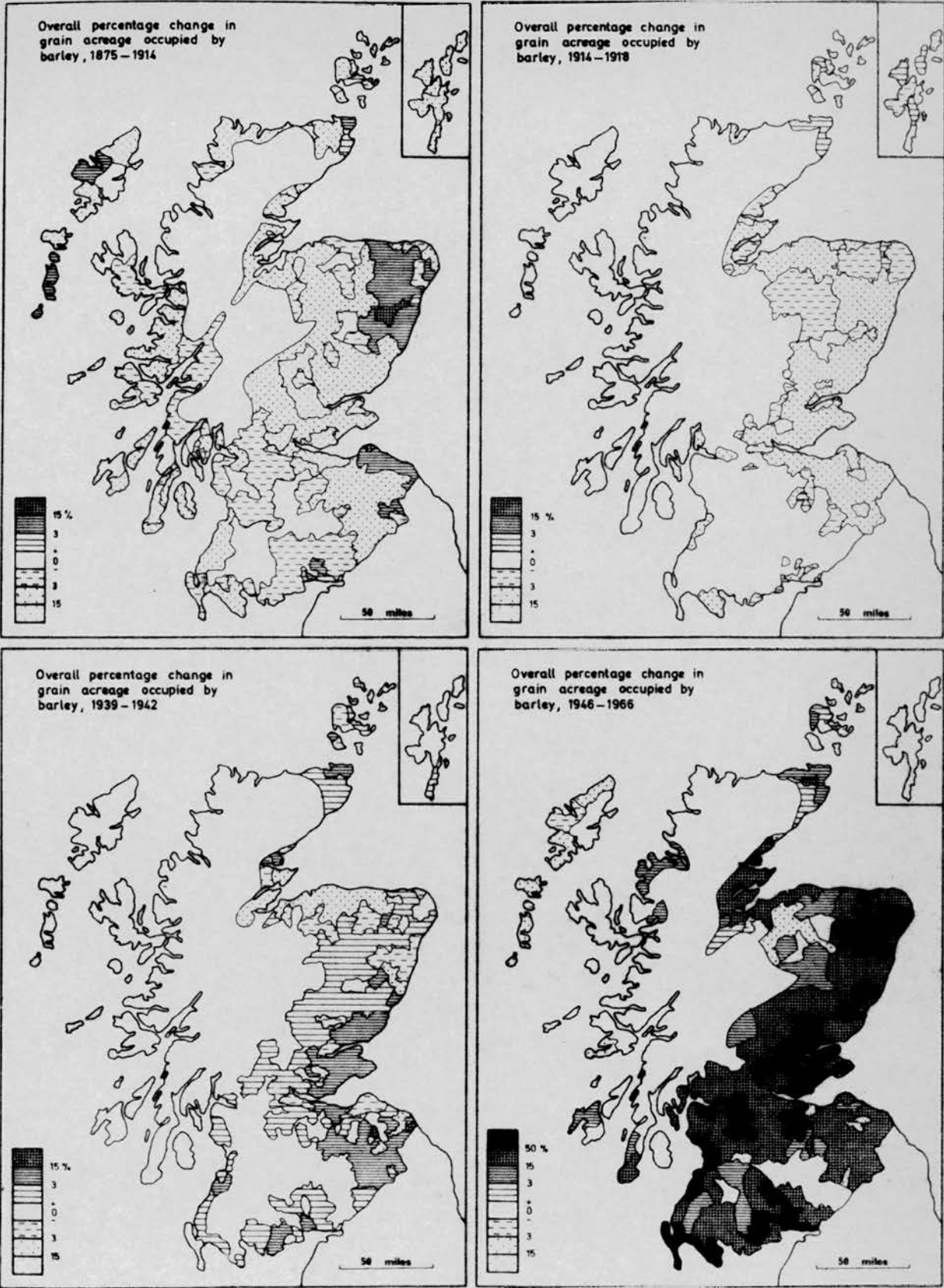
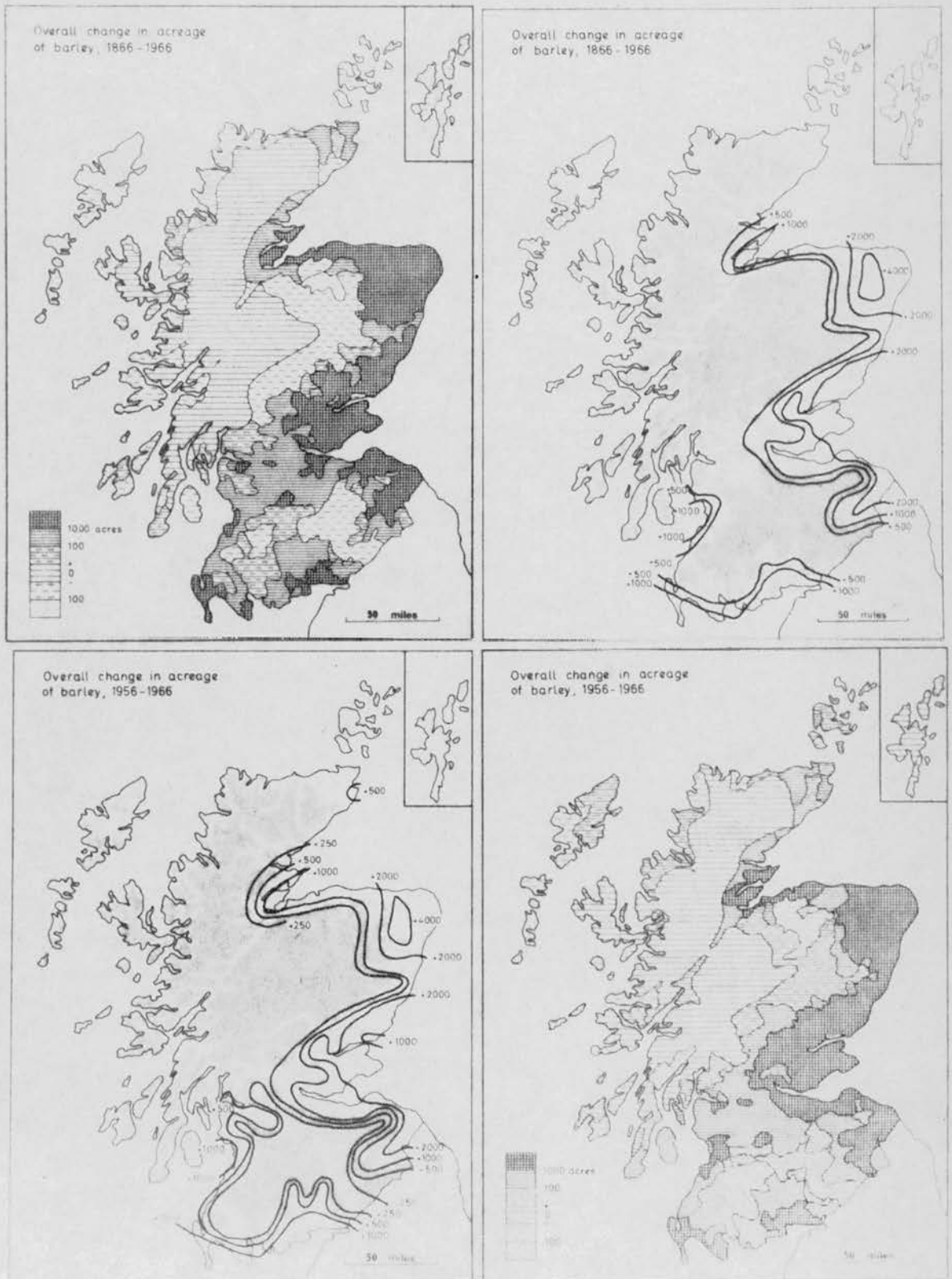


Figure 113

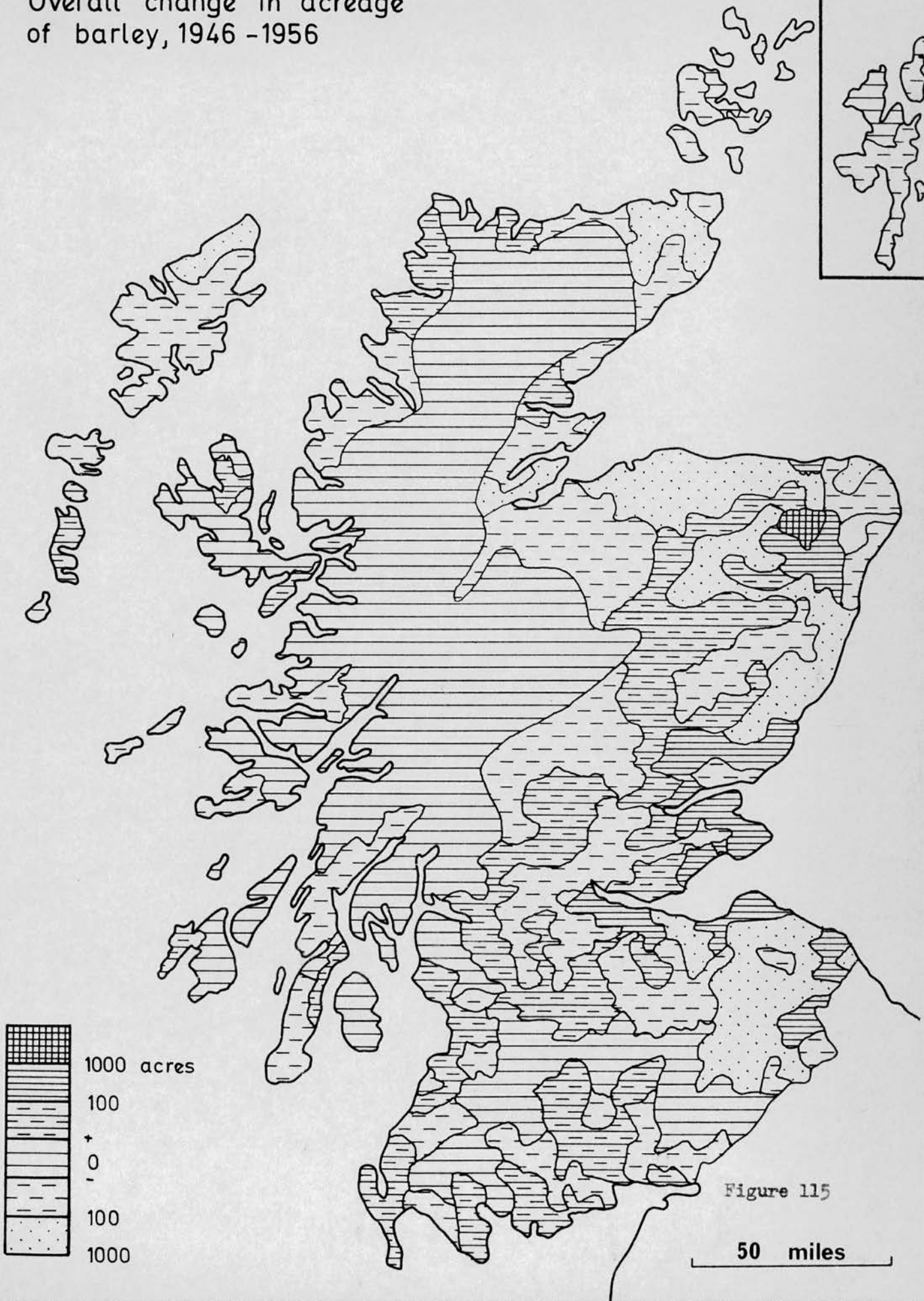
Overall Acreage Change Maps

The actual overall acreage changes are used to ensure that areal comparability difficulties between percentages representing very small parishes of intensive grain production do not get distorted when comparing with larger ones, especially in the better arable areas. The overall 1866-1966 map (Figure 114) should look similar to the 1956-1966 one since it is already apparent that the main changes of the century were in the last decade. In fact it is fundamentally the same map, with no substantial additional story to tell except that the light positive acreage changes of part of upland Perth, Angus, Aberdeen and Inverness between 1956 and 1966 were not enough to repeat higher acreages recorded in the early part of the century. A comparison with the line graph barley pattern for upland Inverness reveals this very clearly.

Isoline maps were prepared to match the 1866-1966 and 1956-1966 maps and they serve to localize some of the concentrations of barley in a way that the density shaded maps do not. The isoline maps are drawn on the basis of combined parishes in the lowland arable areas. The map of acreage change 1946-1956 (Figure 115) is inserted to give the interim picture as the popularity of barley as a crop gathered momentum for its later massive expansion. On the acreage basis the two parishes of Auchterless and Fyvie in central Aberdeen are revealed as major concentrations of barley growing though this fact is hidden entirely on the 1946 and 1956 fixed percentage maps. All of the density shaded maps for barley suffer from the problems of areal comparability which the varying sized parish administrative reporting units introduce.



Overall change in acreage
of barley, 1946 - 1956



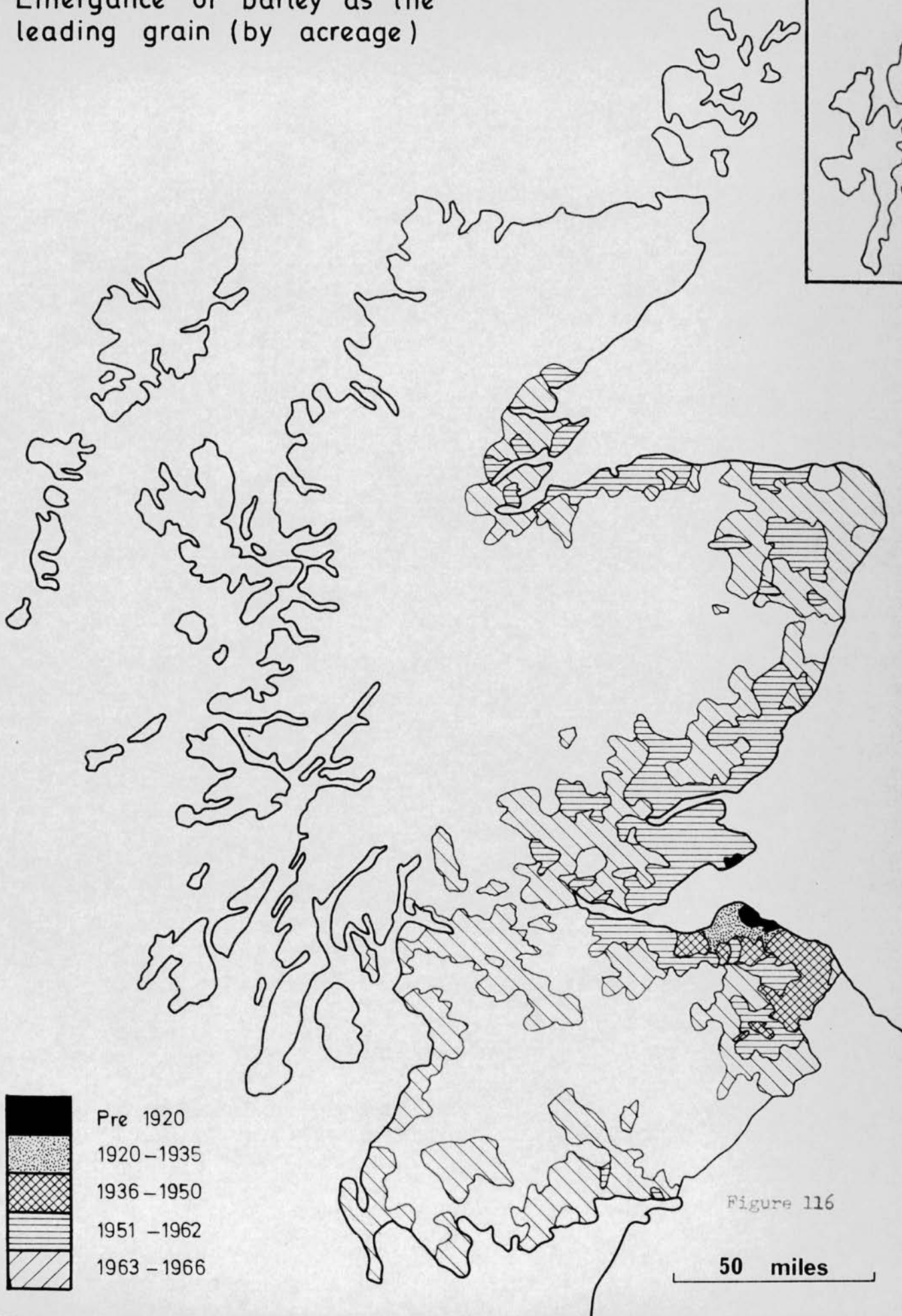
The Emergence of Barley as the Leading Grain Grown

Two maps illustrate a sample of the emergence of barley as the leading grain grown. The first shows the period when barley emerged as the leading grain but not as the overall dominant grain (Figure 116). The parishes of St. Monans in Fife and Dunbar in East Lothian have had such a pattern from 1866 or earlier and Whitekirk, East Lothian from 1875. The second map gives the period when barley exceeded total other grains by 200 per cent or more (Figure 117). Using a different viewpoint of relationships, these maps provide another informative set of patterns.

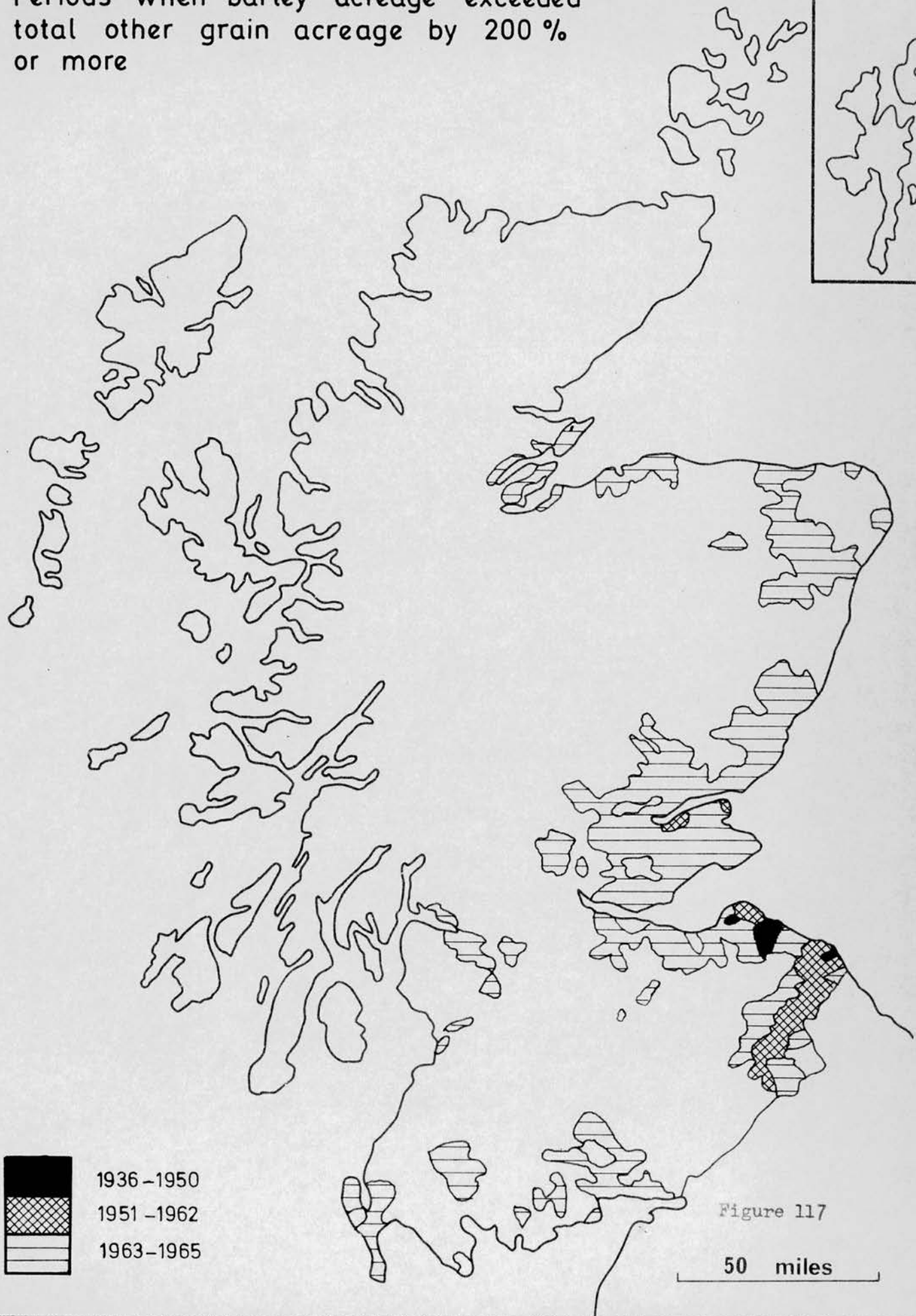
Grain Order of Rank Maps and Graphs

The grain order of rank maps are dominated by new barley patterns only in the last map for 1966 though the nucleus for it was present in 1866. The 1866 map (Figure 118) shows very clearly the extent of oats domination of Scottish grain farming and the 1918 map (Figure 119) continues the pattern with only Dunbar showing a barley, oats, wheat order. In 1943, (Figure 120) the pattern broadens from its base on the south shore of the Forth and into the Merse of Berwick and neighbouring Roxburgh. The map for 1966 (Figure 121) gives barley first place in such a wide area that the map is comparable to the percentage and acreage maps for that year even though it uses a different statistical base. The graphs (Figures 102, 103, and 104 on pages 233-235) for the main barley growing areas (except the Moray Firth region) complete the story by filling in the gaps and putting a date on the changes which took place in the periods between the four sample maps.

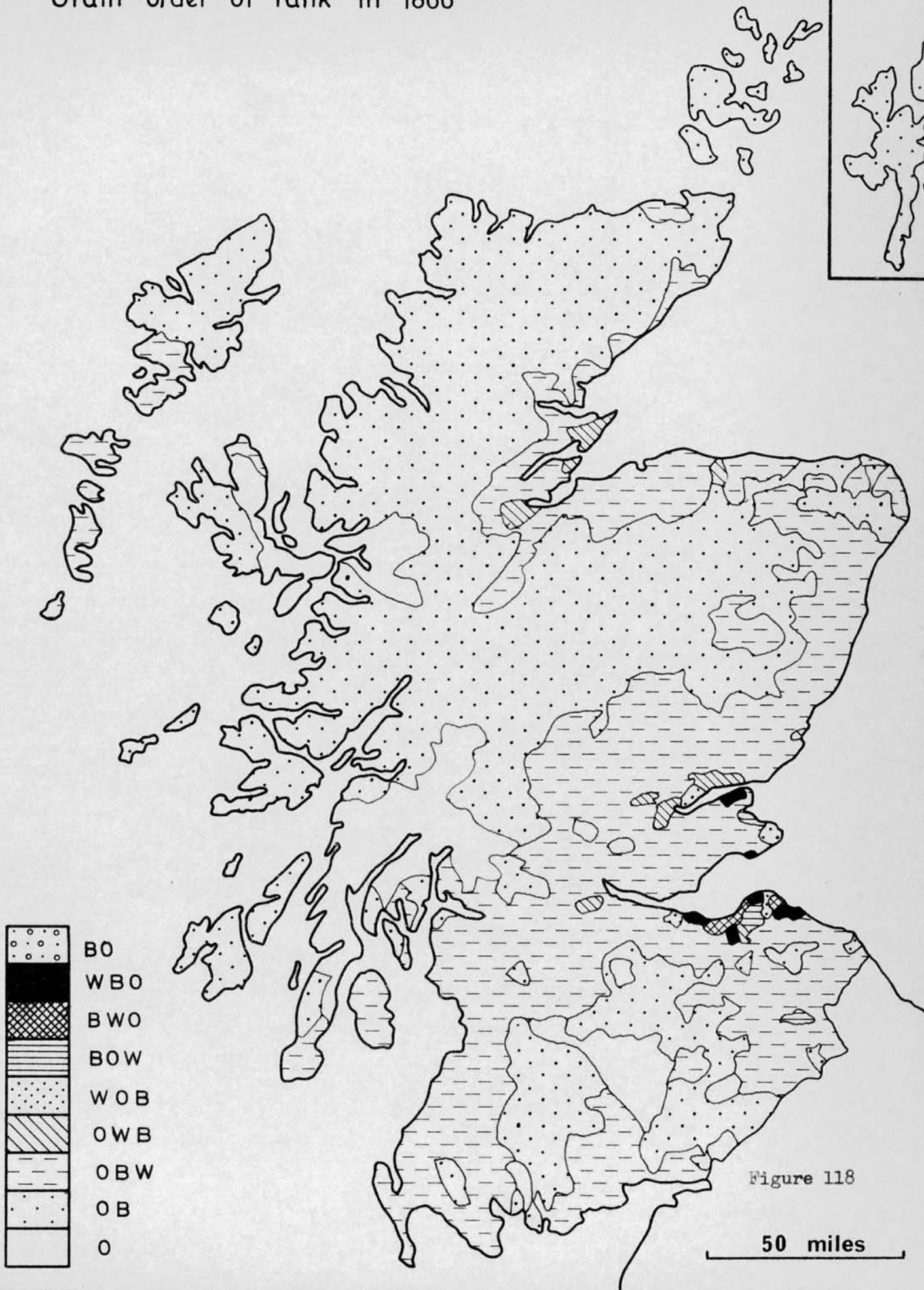
Emergence of barley as the
leading grain (by acreage)



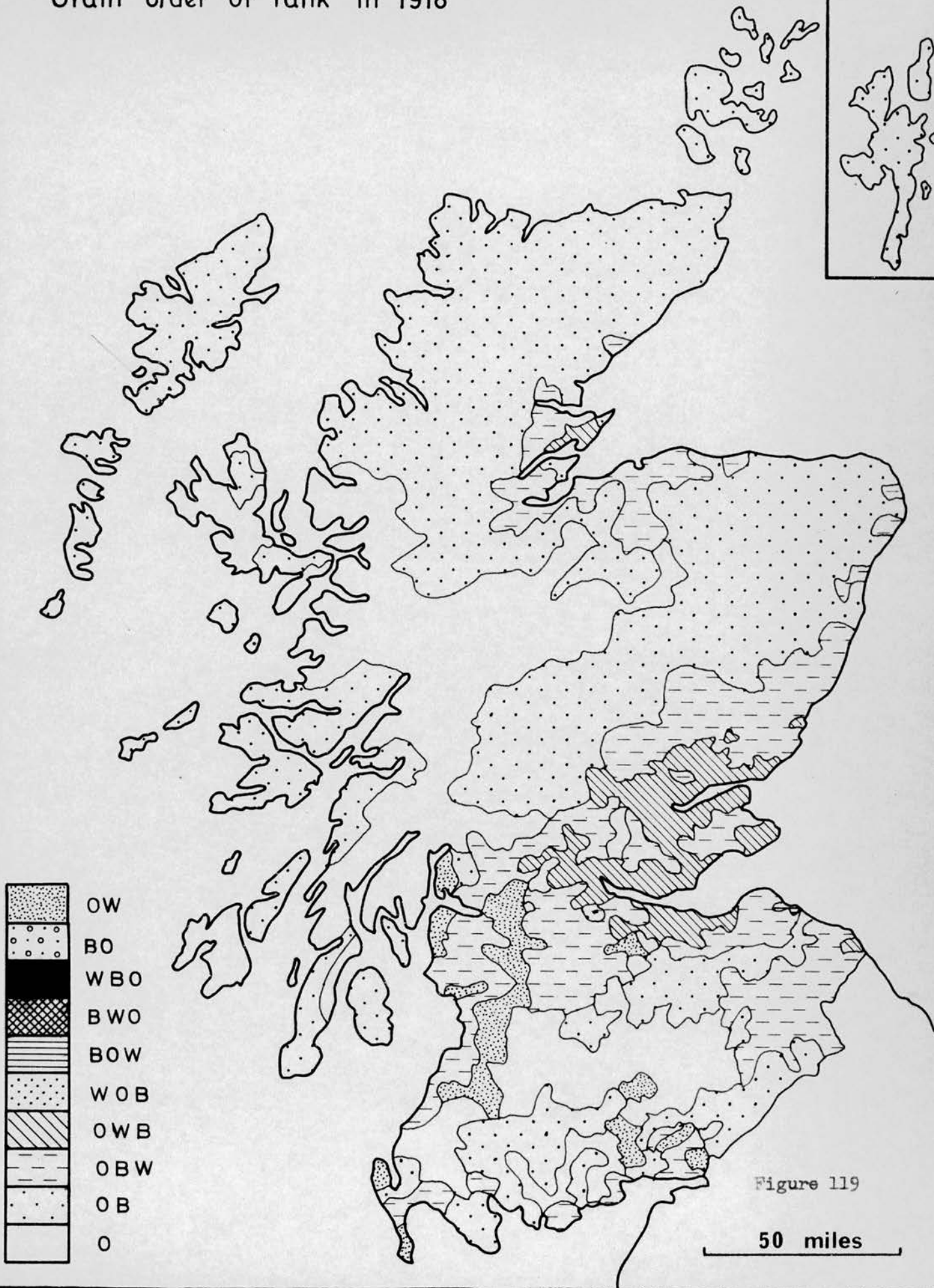
Periods when barley acreage exceeded
total other grain acreage by 200 %
or more



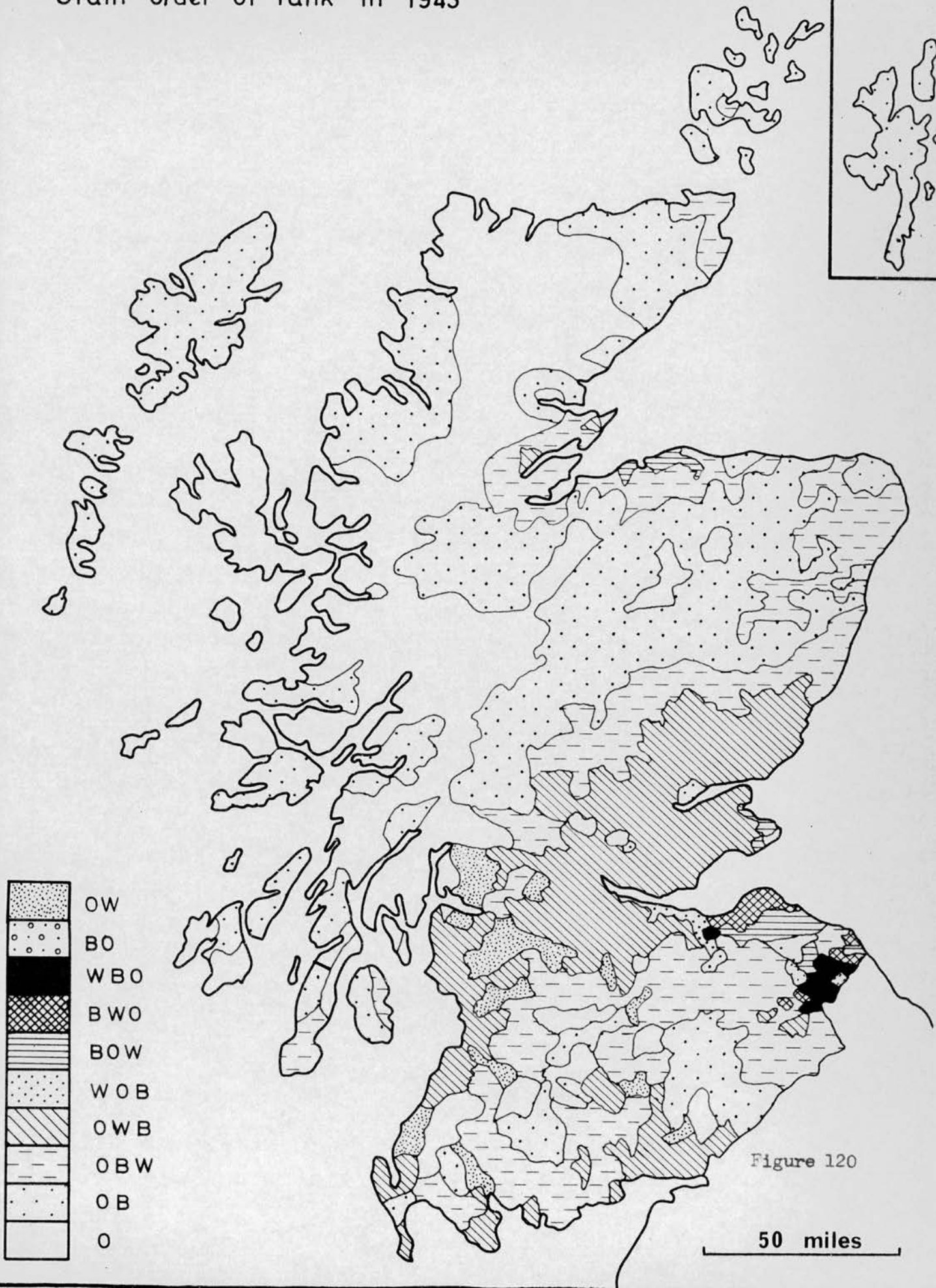
Grain order of rank in 1866



Grain order of rank in 1918



Grain order of rank in 1943



Grain order of rank in 1966

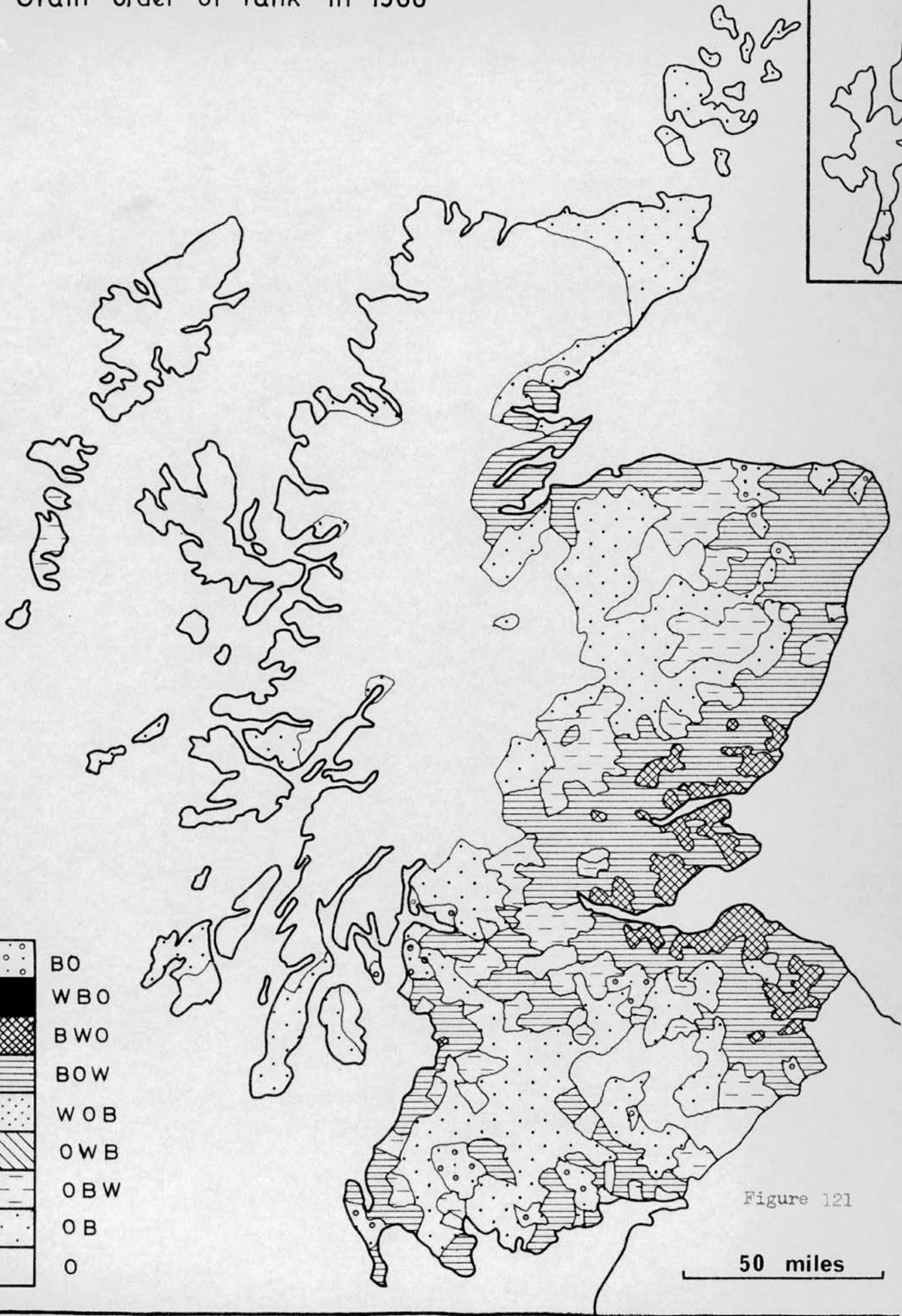
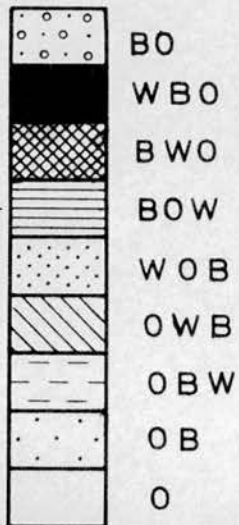


Figure 121

50 miles

Equal Area Bar Graph Sections and Section Maps

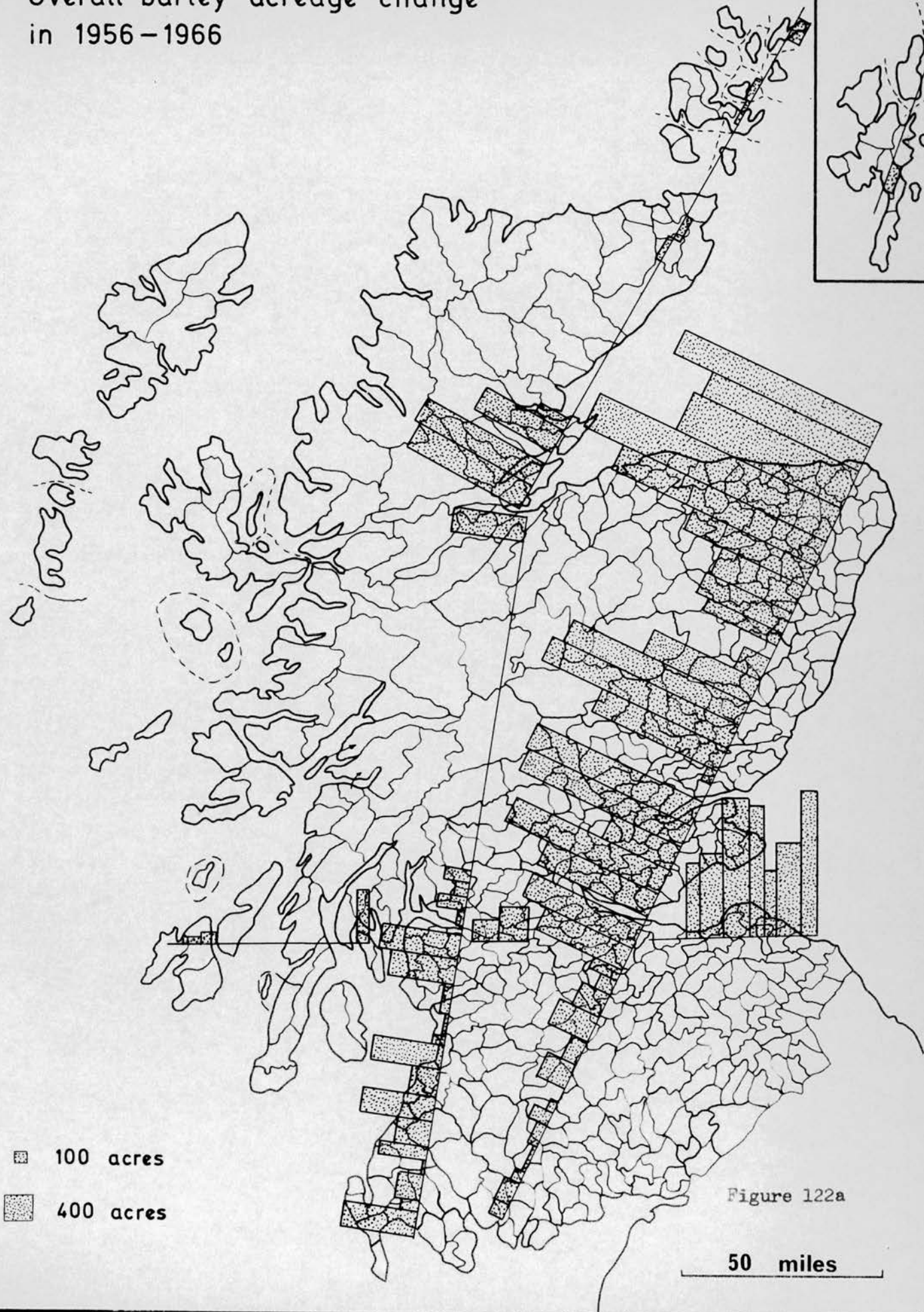
The relative position of barley is readily shown in the section graphs based on grouped parishes and single parishes and relating to 1866, 1942 and 1966 (Figures 76-81 on pages 186-191). The changes are very striking. The patterns are continued on the section maps and aid in giving the barley acreage concentrations a regional perspective (Figures 84a, 84b and 84c on pages 196-198). In addition the two overall acreage change section maps (Figures 122a and 122b) give a graphic regional emphasis which offers the expected details in a fresh form and from a new viewpoint, 1956-1966.

The barley overall acreage change section maps strongly stress the Moray Firth, Aberdeen, Firth of Tay, Firth of Forth and Merse of Berwick and adjacent lowland Roxburgh, as the leading barley growing regions. The positive changes to larger acreages between 1956-1966 in Wigtown, Ayr and Renfrew are given prominence as expected as well as those small negative changes in Caithness, Orkney and Shetland where barley growing in the parishes shown is something of a gamble. The section maps are used here to demonstrate their value in change situations as well as in fixed one year patterns.

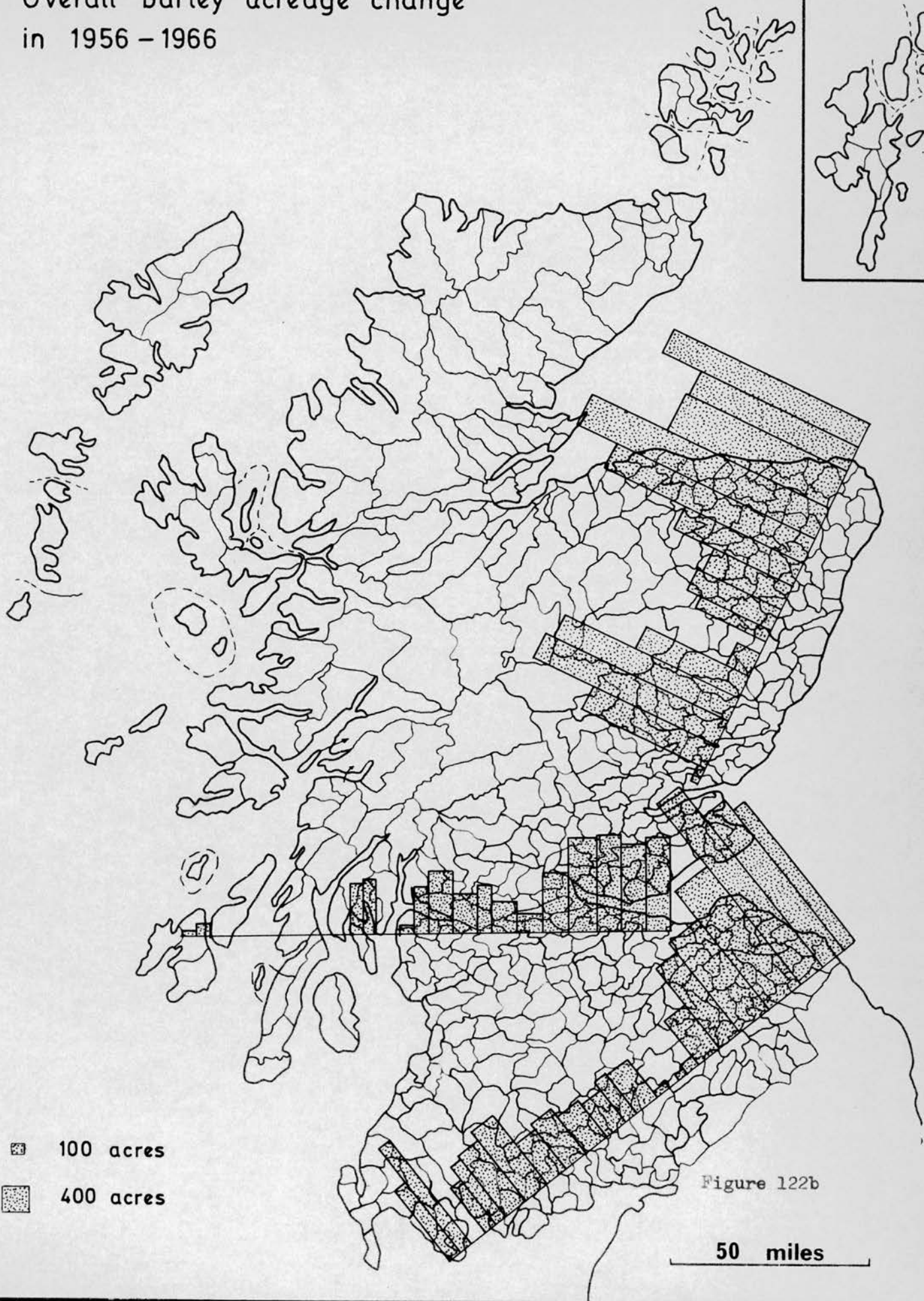
Regionally Based Bar Graph Maps

The bar graph map showing the position of barley by grain regions in the sample years 1867, 1896, 1914, 1918, 1939, 1942, 1960, and finally in 1965 (Figure 123) gives another dimension and offers the changes over a century in 8 key years. The map speaks quite expressively for itself and gives a most useful picture of the regions of influence.

Overall barley acreage change in 1956-1966



Overall barley acreage change
in 1956 - 1966



Overall acreage change,
barley 1956 - 1966

□ 400 ACRES

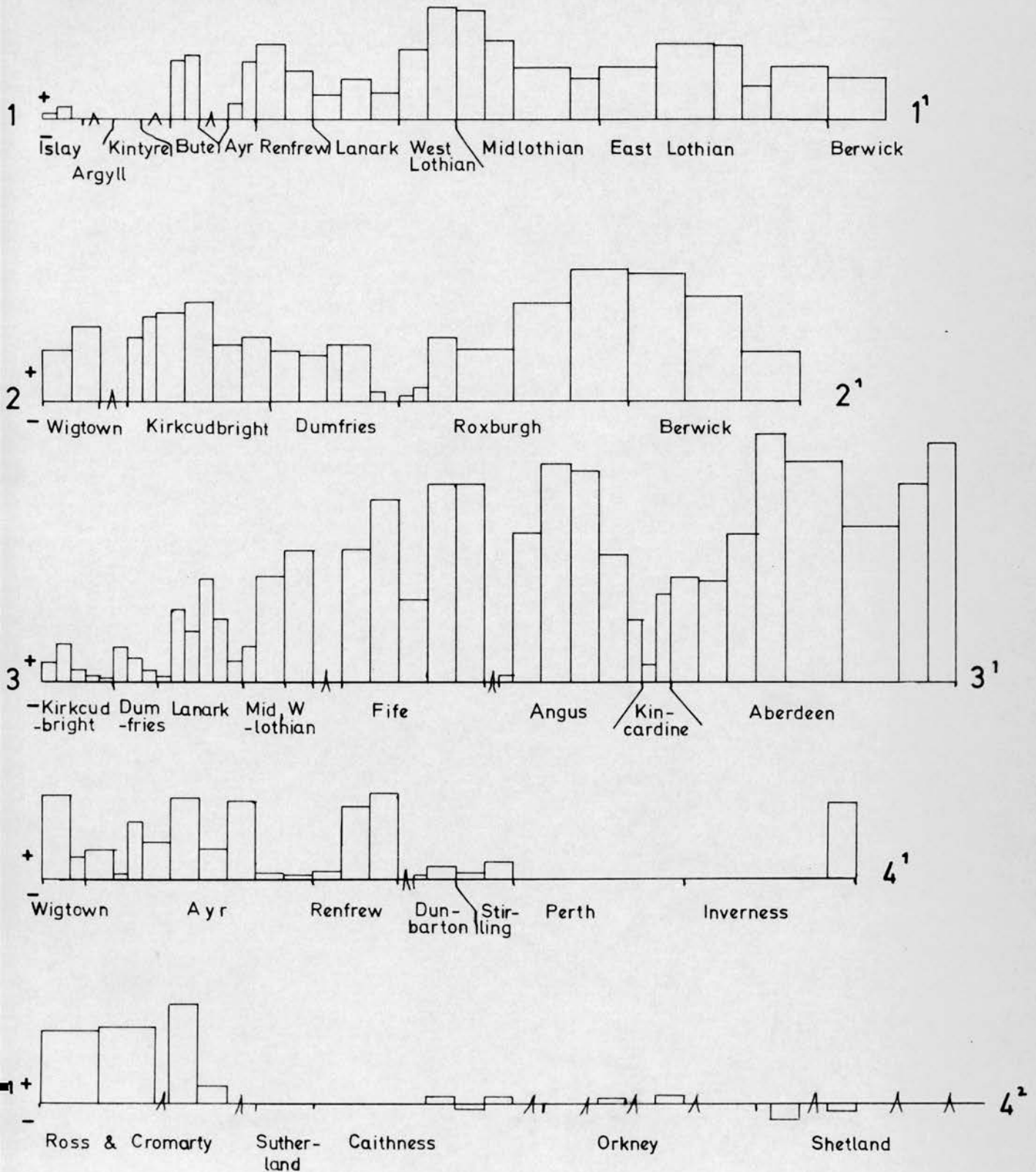


Figure 122c

Regional percentage share
of barley acreage and output
in selected years 1867-1965

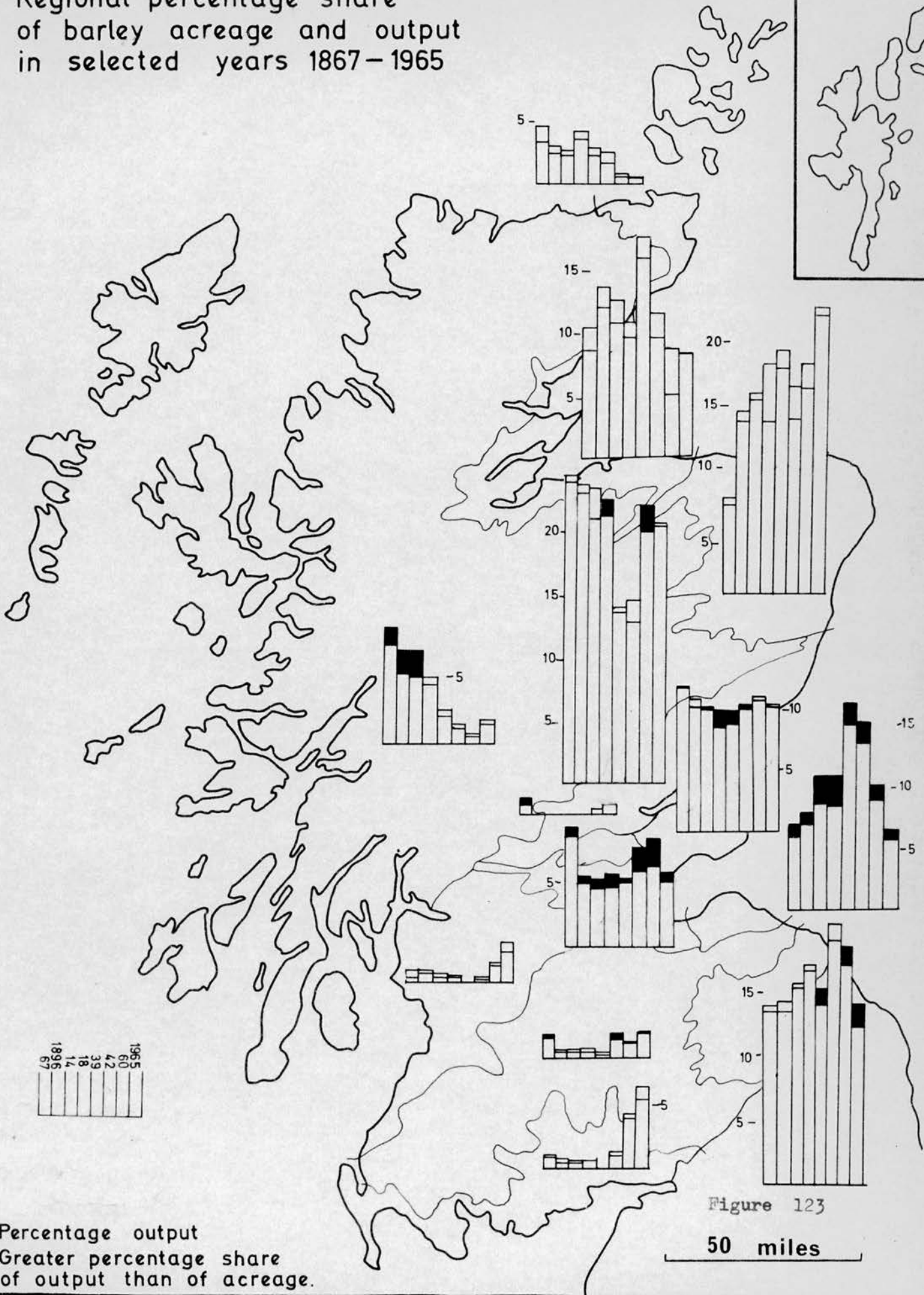


Figure 123

50 miles

Percentage output
Greater percentage share
of output than of acreage.

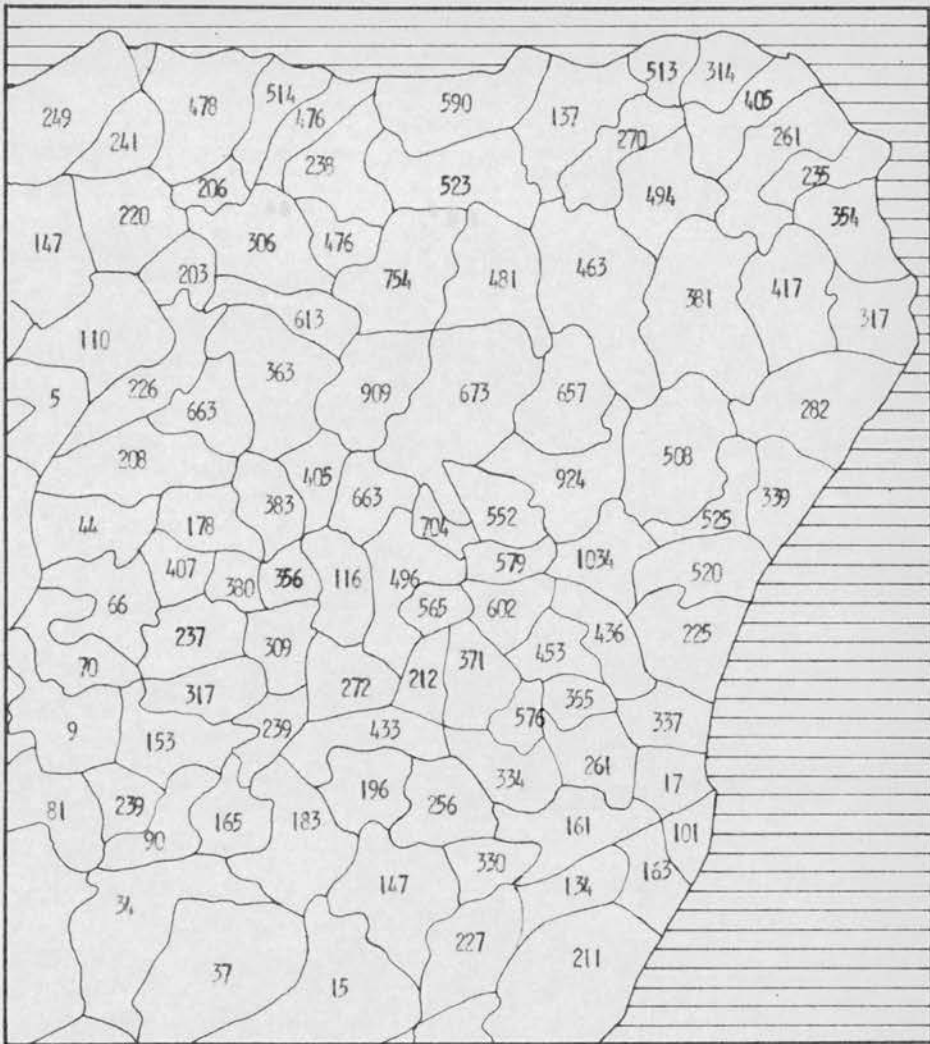
Raised Statistical Surface Maps

The raised statistical surface maps for 1866 and 1966 (Figures 86 and 87 pages 203 and 204) are by divided counties and with total acreages (in 10,000's of acres) imprinted on the raised sections offer some useful comparative details. The most interesting thing about them is the change in the ratio of the grain components with barley taking a very large position in 1966 and wheat losing a good deal, as well as oats, to make way for the expansion. In addition the change in emphasis on grain as a whole is well illustrated in the west and southwest. As a result the barley acreages of 1966 are not related to the same amount of total grain as those in 1866 and this helps their percentage position in 1966.

Unit Area Barley Acreage Stepped Frequency Surface Diagrams

The parishes of Udney, Tarves and Auchterless have the largest acreages in the unit area comparative basis in the arable Aberdeen area (Figure 124). Since the vertical scale used gives 1 millimetre to 25 acres, a number of parishes are hidden in the area behind taller columns. Another viewpoint would solve this problem and in this particular situation two opposite viewpoints are necessary. At any rate, the hidden values are supplied on the accompanying key maps. The diagram is an excellent sample of the results to be expected from the unit area approach.

In the section south of the Forth (Figure 125) a different vertical scale of 1 millimetre to 50 acres was used. A close examination of the diagram pattern reveals that



1 unit = 5 mm² or 14.7 sq.Kms

(1:625000)

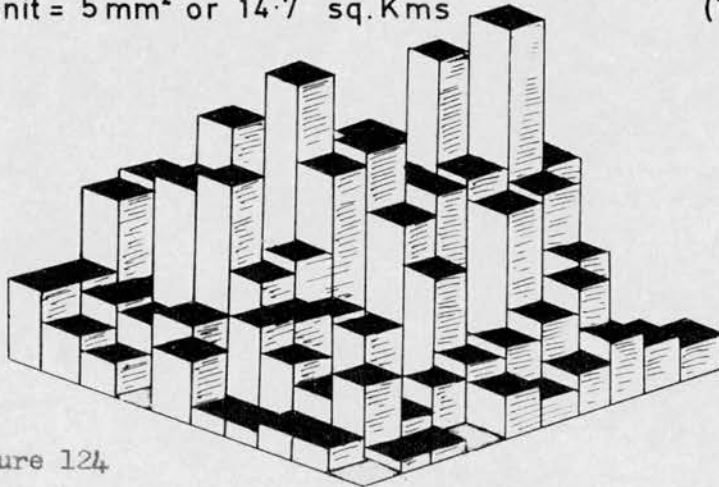
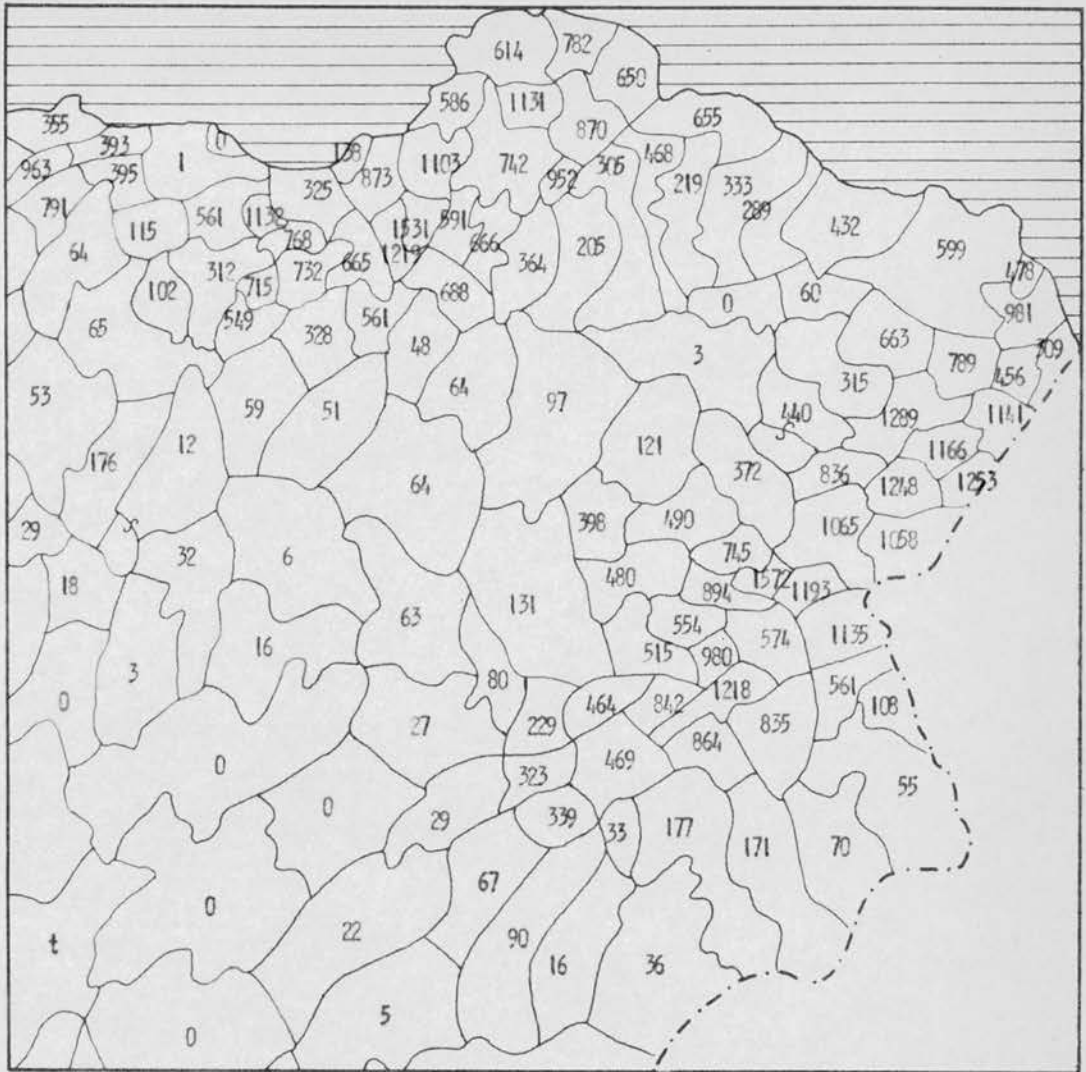


Figure 124

Vertical scale- 1mm. : 25 acres

Acres of barley per unit area in 1966



1 unit = 5 mm² or 14.7 sq.Kms

(1:625000)

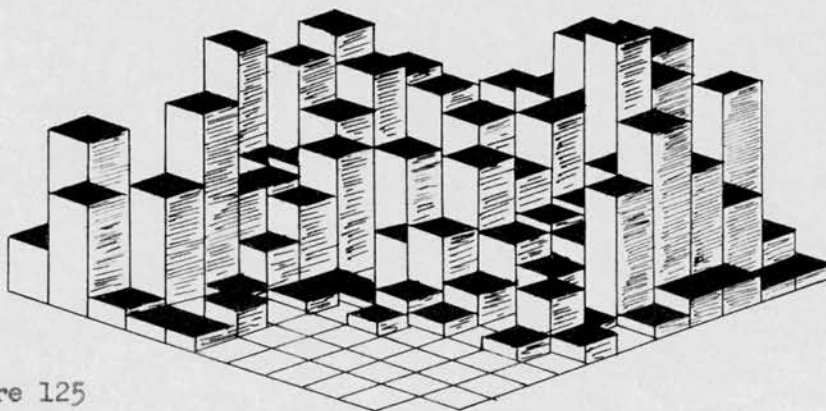


Figure 125

Vertical scale - 1mm. : 50 acres

Acreage of barley per unit area in 1966

barley is grown in two main block groupings. One grouping is north of the Moorfoot and Lammermuir Hills and bounded on the west flank by the Pentland Hills. The other group is in the Merse of Berwick and lowland Roxburgh. The values for the unit areas in the corner may be seen on the key map. The unit area approach using a diagram and a key map offers the only satisfactory technique attempted to improve areal comparability and the key maps may be shaded to express density patterns or used as the base for isoline mapping. The stepped frequency surfaces were not smoothed into a curved trend surface because of a severe loss of detail in the two areas used in the experimentation. However, now that the experiment has been carried on a few stages with a wide variety of category content, some good samples for stylized trend surface presentation may be selected. The barley surface for the Merse of Berwick would make an excellent curved trend surface.

Acreage Number Pattern Maps Based on Unit Areas

The number pattern maps in the same unit area series have been prepared to demonstrate an improvement of technique in preparing number patterns. The patterns for the greater part of arable Aberdeen and the South Forth area (Figures 126, 127, 128 and 129) offer retrievable comparative information lacking in the diagrams. In northern East Lothian (Figure 129) over 50 per cent of the available crops and grass is devoted to grain but the parishes bordering on the Lammermuir Hills show a reduced percentage. The most consistent example of a hill parish is Longformacus with only 6 per cent of crops and grassland in grain. In these maps crops and grass is given in

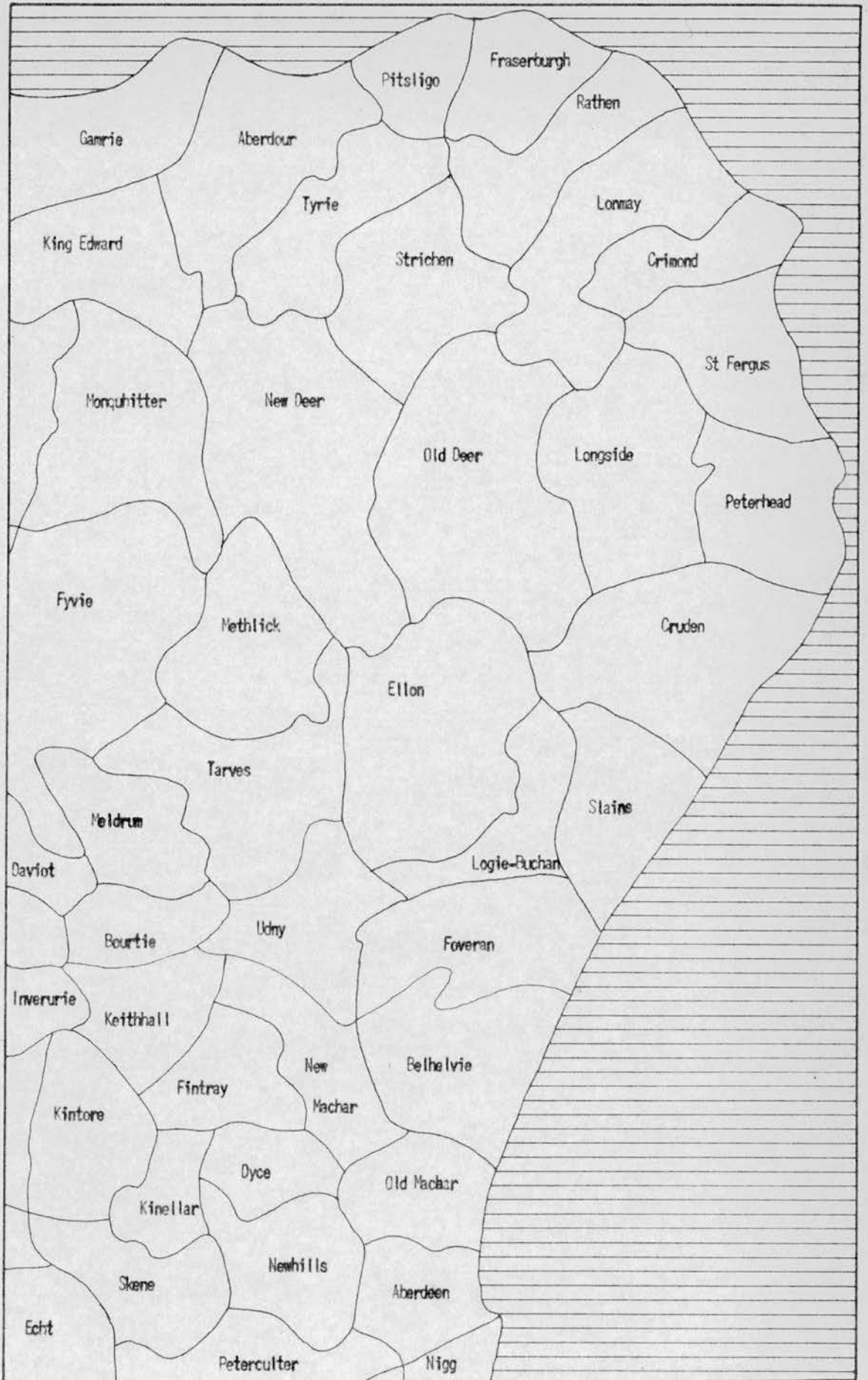


Figure 126

Part of Section One- Aberdeen giving the names of the parishes for which number patterns have been devised on a unit area basis.

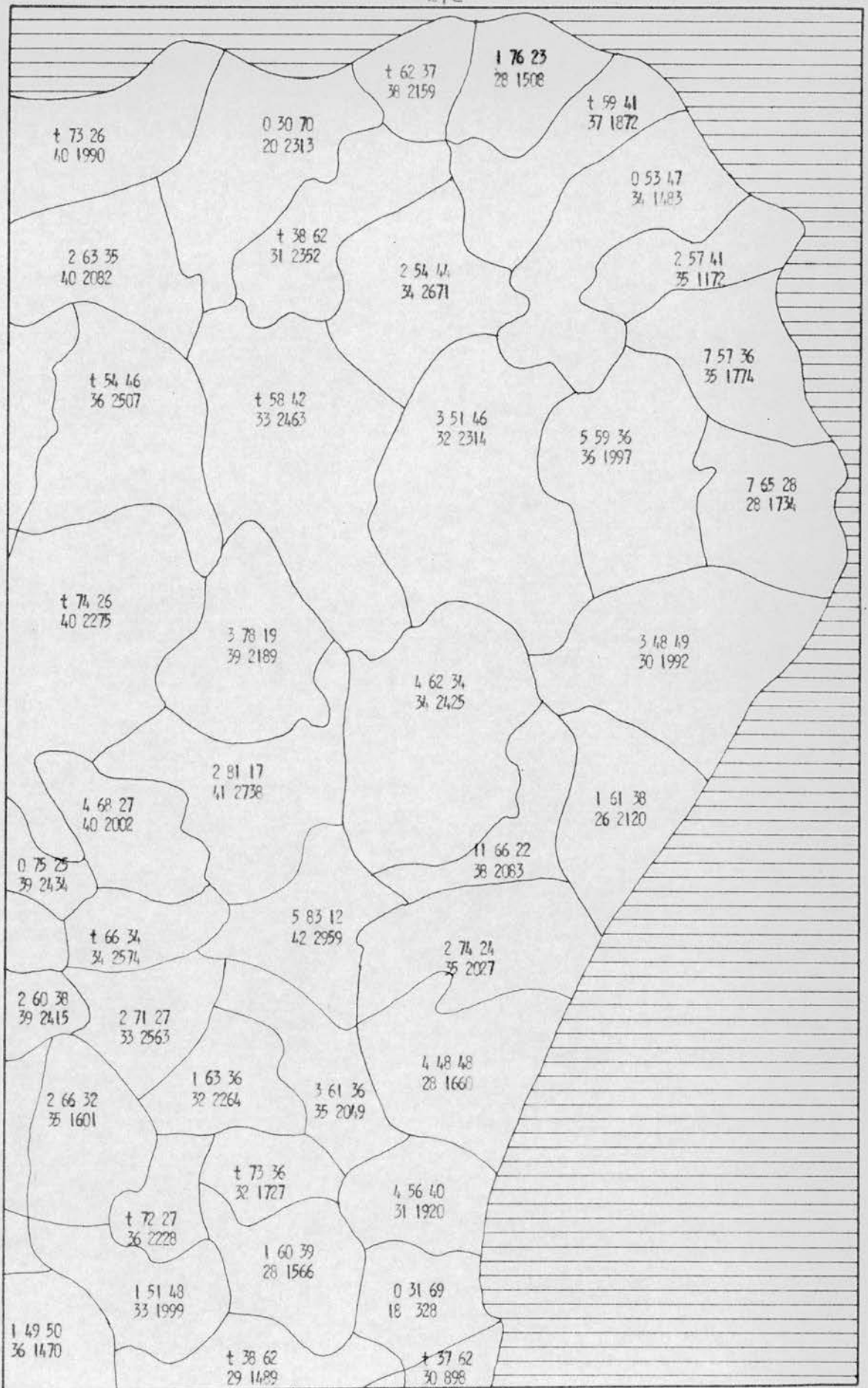


Figure 127

Part of Section One-Acreage Number Patterns. The percentage of land in grain occupied by wheat, barley and oats per unit area of 14.7 sq.kms. is shown in the top line. The percentage of crops and grass acreage devoted to grain, and the actual crops and grass acreage per unit area of 14.7 sq.kms. is shown in the second line.

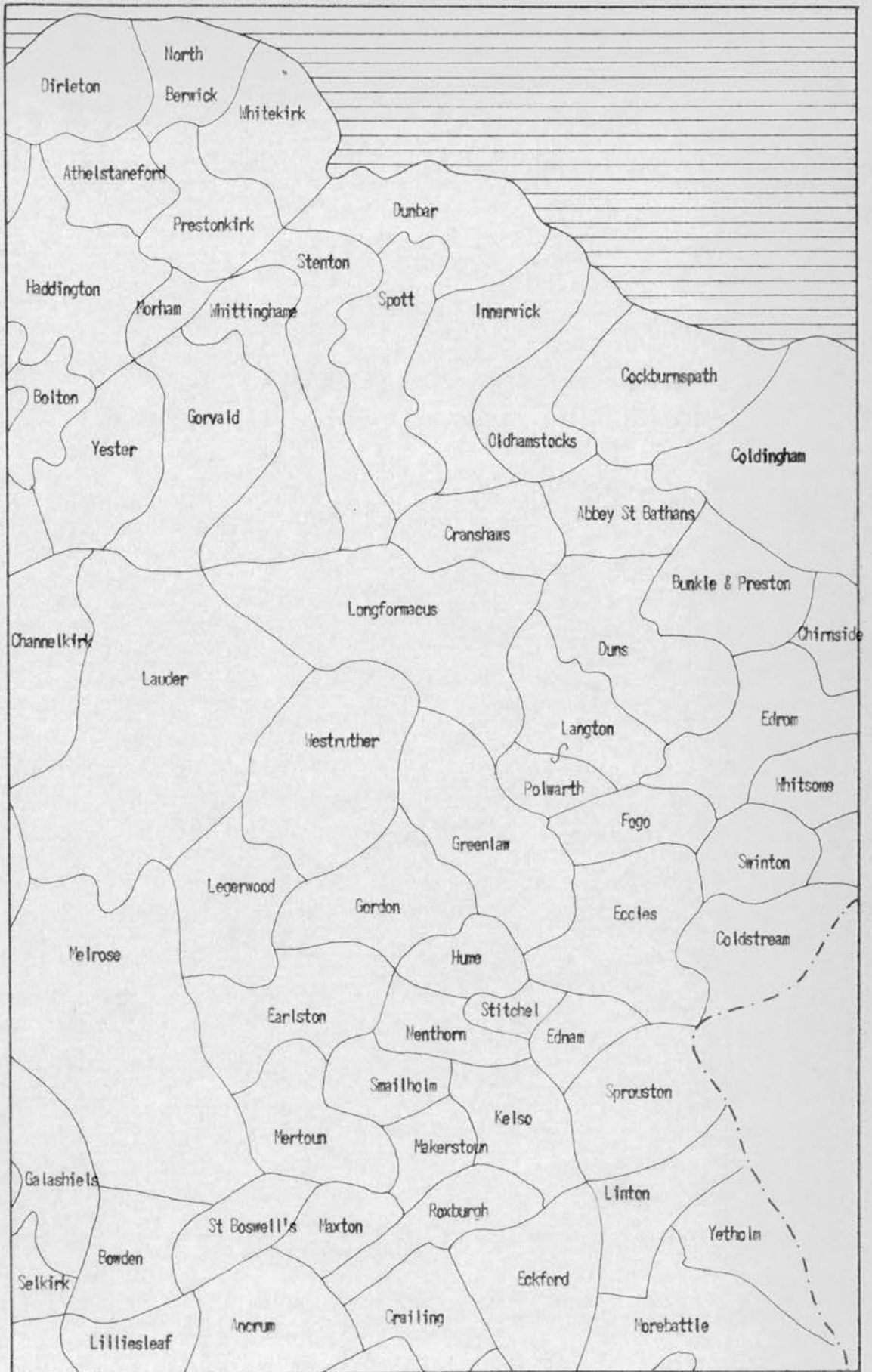


Figure 128.

Part of Section Two- giving the names of the parishes for which number patterns have been devised on a unit area basis.

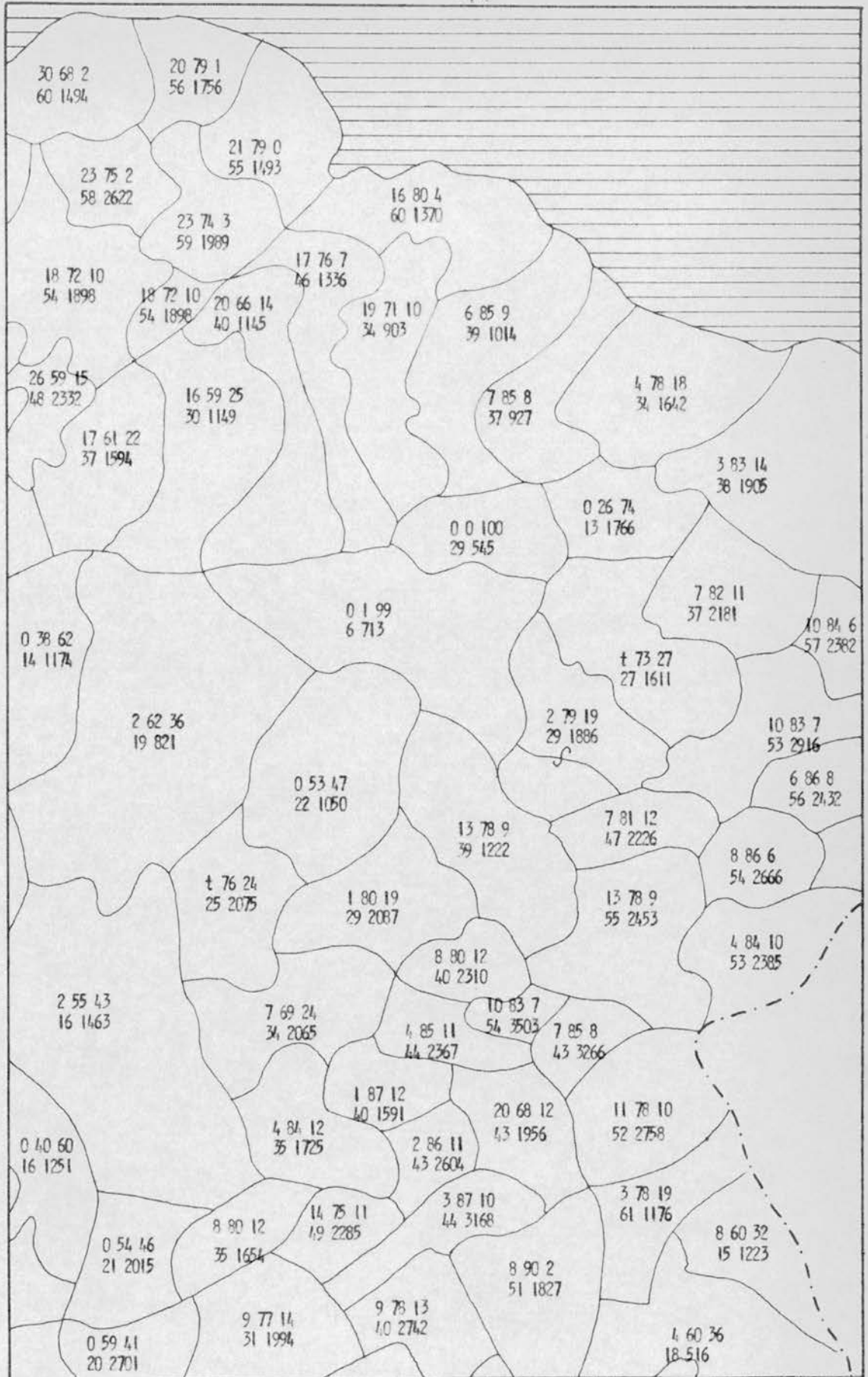


Figure 129

Part of Section Two—Acreage Number Patterns. The percentage of land in grain occupied by wheat, barley and oats per unit area of 14.7 sq.kms. is shown in the top line. The percentage of crops and grass acreage devoted to grain, and the actual crops and grass acreage per unit area of 14.7 sq.kms is shown in the second line.

total acres not in hundreds of acres as in the country-wide scale number patterns in Appendix D. The position of barley in the number patterns in Figures 127 and 129 needs no further comment.

The Changing Pattern of Oats Distribution

Scotland's reserve of good grain growing land was used to near capacity in 1966 and generally throughout the century with some exception for the period 1921-1939. Oats have always been grown wherever grain is grown and in many areas of the highland-uplands and islands the word oats is synonymous with the words grain, corn or cereal. Consequently if there is to be a trend to more oat growing ¹ in areas where there is an alternative, a switch from either wheat or barley is necessary, since the economic land is already used. No new land can be brought into use quickly and even if reclamation was a large scale policy the results to be achieved from such new land is not comparable to the results from improving yields per acre on the land already in use. Such land is amenable to improvement by adopting more intensive field practices, heavier sowing and the use of more fertilizer, whether artificial natural or green, and the use of the newer grain varieties which have been selected for yielding ability and adaptability to a variety of field conditions.

Considerable research has accumulated over the past half century in the development of new grain varieties. The oat

1A swing back to oats in England has been confirmed in the survey of grain seed sales carried out by the National Association of Corn and Agricultural Merchants. This information was reported in a Press item in the Agricultural Reports, The Times, June 12, 1967.

variety trials in the East of Scotland between 1958 and 1963 tested the performance of 22 new varieties.¹ The tests were carried out in a number of test areas in varying conditions of land fertility, exposure, height, and local climate. In 1967 four of the varieties tested in the earlier period were still on the recommended list and three others had been added.² The oats grown in recent years stand out in strong contrast to the oats of a century ago, for weight, quality, smoothness, reduction of husk fibre, stooling abilities of the growing plant and quality of the straw. Nevertheless, a bushel of oats does not command the prices that are obtainable for high quality barley and it has not been regarded as a cash crop so much as a feed grain, the large part of which is consumed on the farm. Most Scottish farmers have few alternatives but to grow oats and barley, so that the switch from barley desired by the Home-Grown Cereals Marketing Board³ would mean the loss of a revenue crop with nothing to replace it.

Line Graphs

An examination of the line graphs (Appendix C) is almost an anti-climax at this point, since the patterns

1. Field Experiment Committee, Oat Variety Trials in the East of Scotland, The Edinburgh and East of Scotland School of Agriculture, Edinburgh, August 1964.

2. Cereal Variety Recommendations, The Edinburgh and East of Scotland College of Agriculture, 1968, a leaflet offering details of ripening, straw length, resistance to lodging, disease and pests and special attributes of the new varieties.

3. See the references on page 241, calling for a change in cropping patterns, Note 1.

are obvious enough. When barley acreage began to increase so remarkably particularly after 1960, land formerly in oats was turned over to it. Consequently oats acreages were reduced throughout the country but to their greatest extent in the more arable lowlands of the eastern coastal area of Scotland and in the southwest. The oats graphs suffer from their relation to total grain, being the amount left over after plotting wheat and barley and an occasional unplotted amount left over for mixed grain. In the case of oats, the graphs are not easy to follow as what appear to be down-trends may not in fact be so. The addition of figures at the main peaks and troughs makes this clear. If other methods were not to be used to show the position of oats, the line for oats on the graphs would have been more realistic related to crops and grass. If that had been done then the oats position on the graphs would not relate well to the other grains which were at many times in the century, too small and insignificant in acreage to appear on the graphs at all.

Acreage Number Pattern Maps

The year by year pattern of oats in the grain family by the 54 unit divided counties and counties may be seen to advantage in the acreage number pattern maps. In many areas and for most of the 1866-1966 century, oats was the only grain of significance and its lead over the other grains was not a simple one-two-three relationship but one of an overwhelming lead. The entire series of acreage number patterns may be seen in sequence in Appendix D. Though the figures are rounded the individual acreages of the main grains grown may be retrieved.

Distribution Patterns in Density Shaded Maps

Oats as a Percentage of Total Grain Acreage Maps

Ten maps based on parish information are used to supply a sample picture at peak, trough and more average years over the century. When reduced in size and offered in up to four maps on a page, a more dynamic picture emerges. The crop has always been important in Scotland but the scale division from 76-100 per cent applies mainly to those areas which have little alternative but to grow oats and do not grow large acreages of any grain because suitable land is not available. The exception from 1866-1956 was in Aberdeen and Banff which for 90 years grew mainly oats and where only in the last decade to 1966 have alternatives in the new varieties of barley and to a small extent wheat been found. The maps are useful chiefly in the three lower classes on the scale, as an expression of the increasing or decreasing alternative percentages.

In the 1866 and 1875 maps (Figures 130 and 131) the parish areas in the class 26-50 per cent and 51-75 per cent are fairly extensive in the Firths of Forth, Tay and Moray regions. The oats acreage pattern had contracted by 1896 and continued at about the same level in 1914. However by 1918 the percentage of land devoted to oats had increased and the growing of alternatives decreased. This situation continued until 1931 (Figure 132), expanded slightly in 1939 and 1942 and again by 1956. It is in the 1966 fixed percentage map (Figure 130) that reveals patterns offering the most competition for land formerly devoted to oat

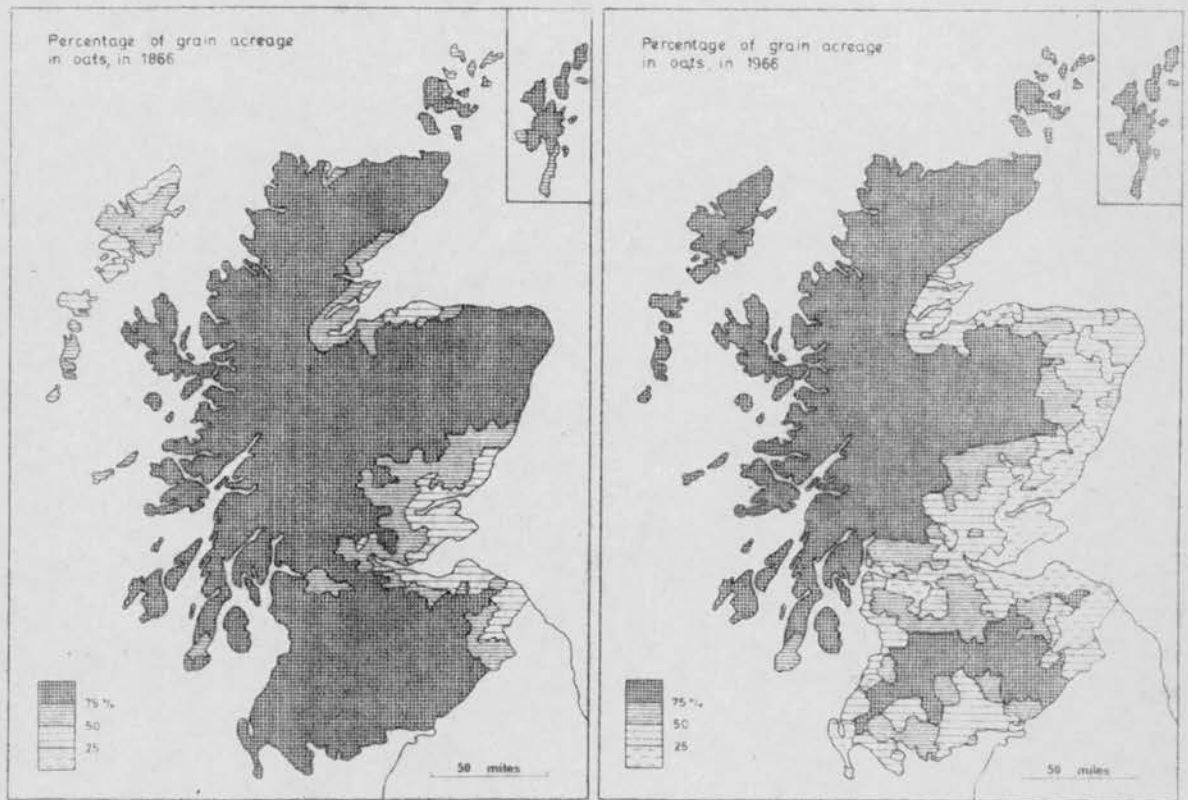


Figure 130

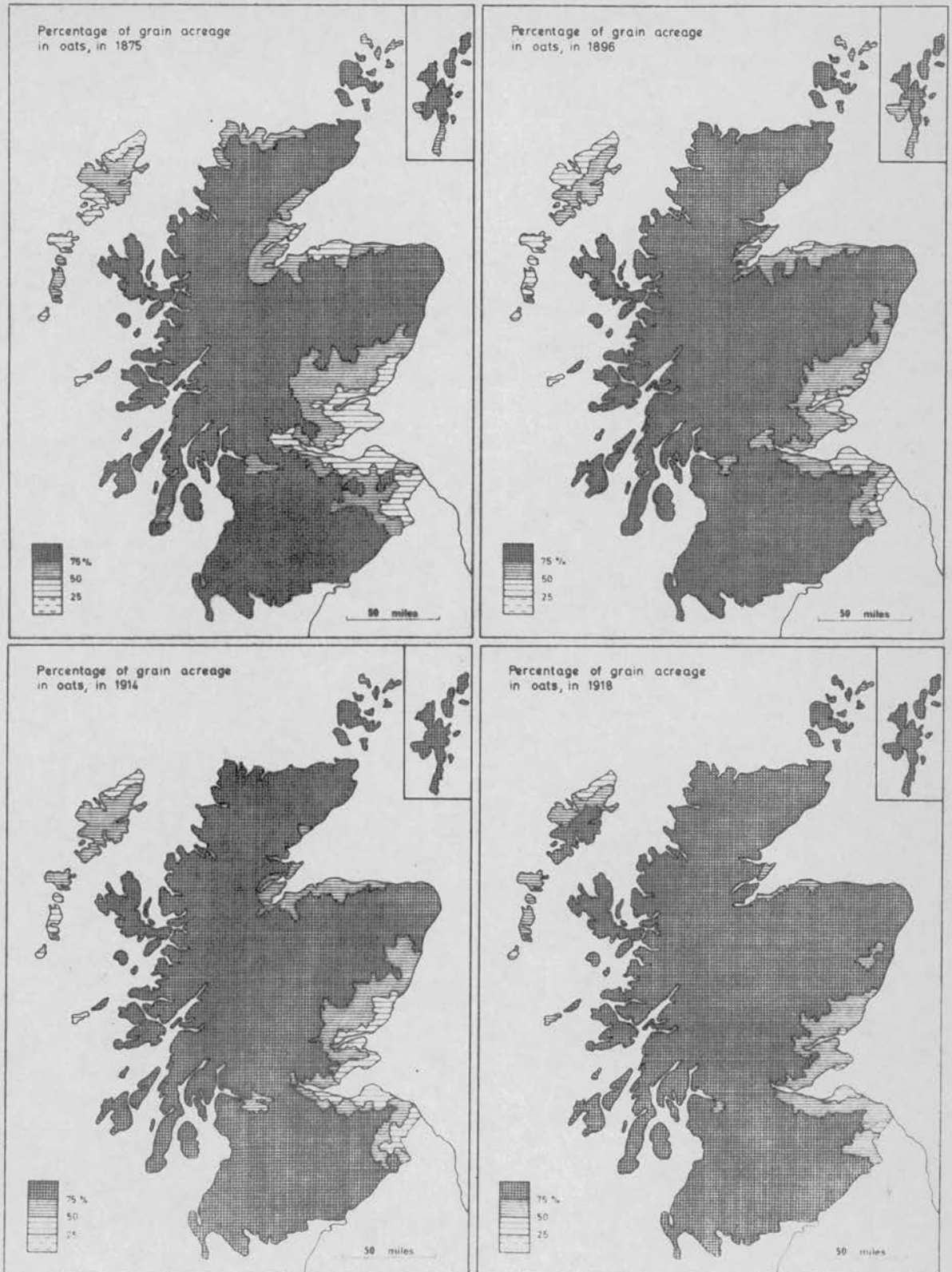


Figure 131

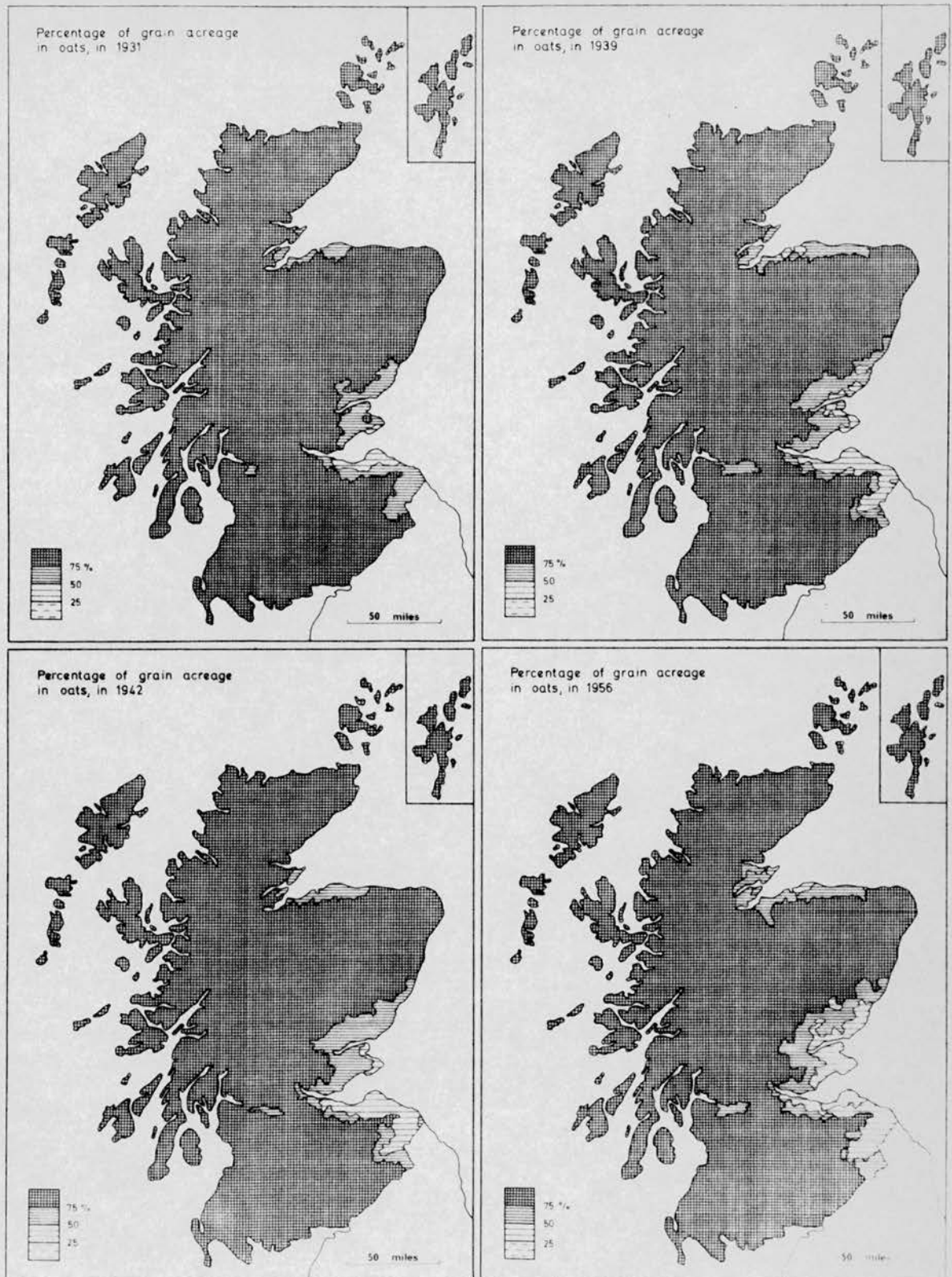


Figure 132

growing when barley acreages increased sharply and extended deeply into the highland edge.

Oats Acreage Maps

Four maps representing 1942, 1950, 1955 and 1966 (Figure 133) reveal some of interesting features and changes of recent years. In a year of high acreages in 1942, there is a large area in Banff and eastern Aberdeen in the highest division of the scale of over 5,000 acres of oats per parish. This large area decreases as parishes reported less acres in 1950 and 1955 and considerably less in 1966. Most of the changes were due to land formerly used for oat growing being used for barley. These maps give far more pattern than the fixed percentage maps for the same or nearly the same years and again offer an illustration of the loss of detail in the percentage ratio form of presentation as was the case with the wheat and barley acreage as compared to percentage ratio density shaded maps.

Oats Overall Percentage Change Maps

As the imports of wheat from the New World countries began to swamp the home market after 1875, the 1875-1914 change map (Figure 134) is forecastable. It tells a story of overwhelming change back to the old reliable oats, which could at least be fed to the farm livestock when it was over-abundant.¹ The main exception to the pattern is in Aberdeen, Banff and Kincardine where the overall change map records a decrease of oats. Between 1914 and 1918 oats acreages increased yet further at the expense of other grain

¹ Imported rough feed grains also competed with home grown grain but where there were no alternatives oats was still grown.

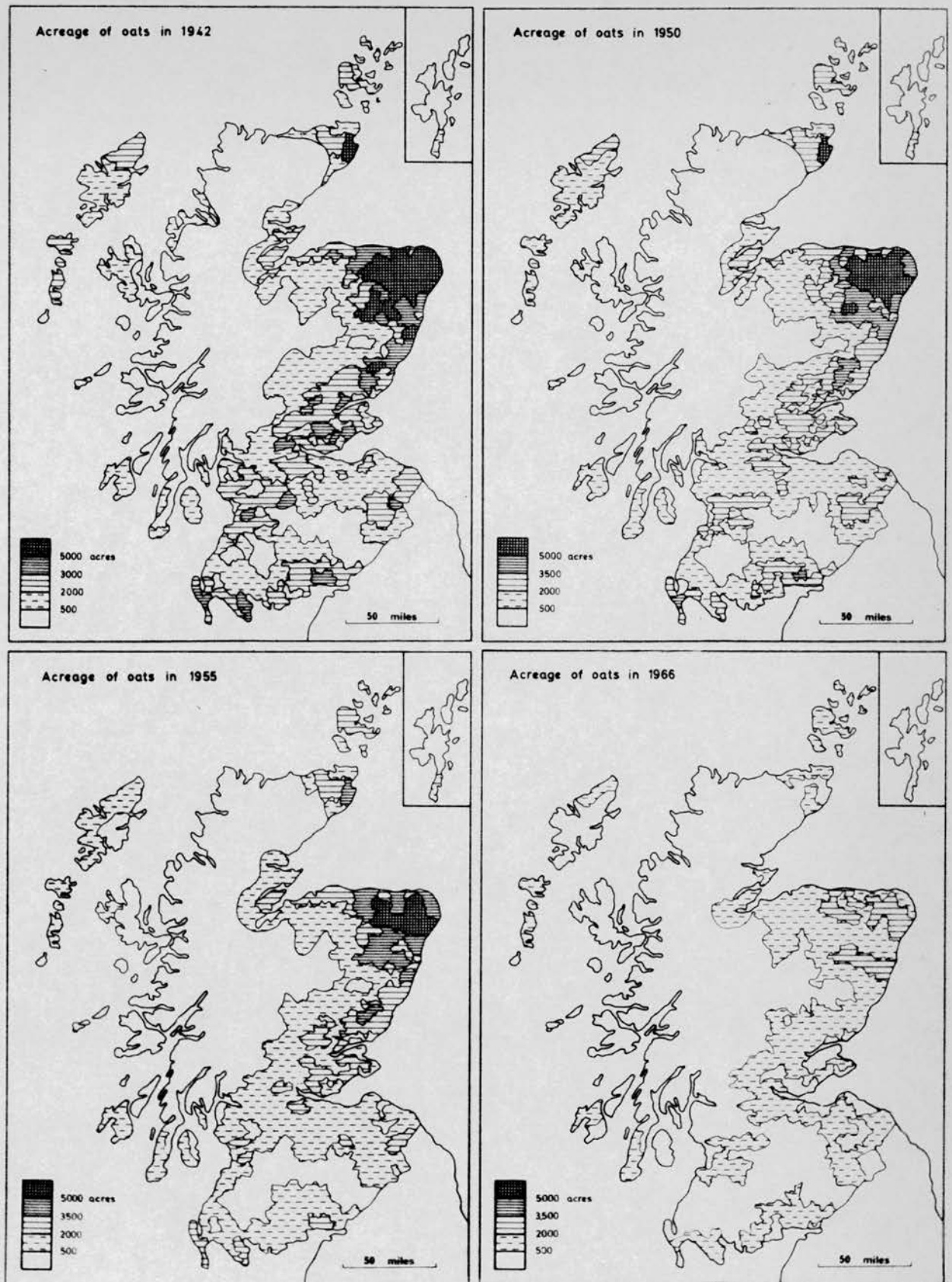


Figure 133

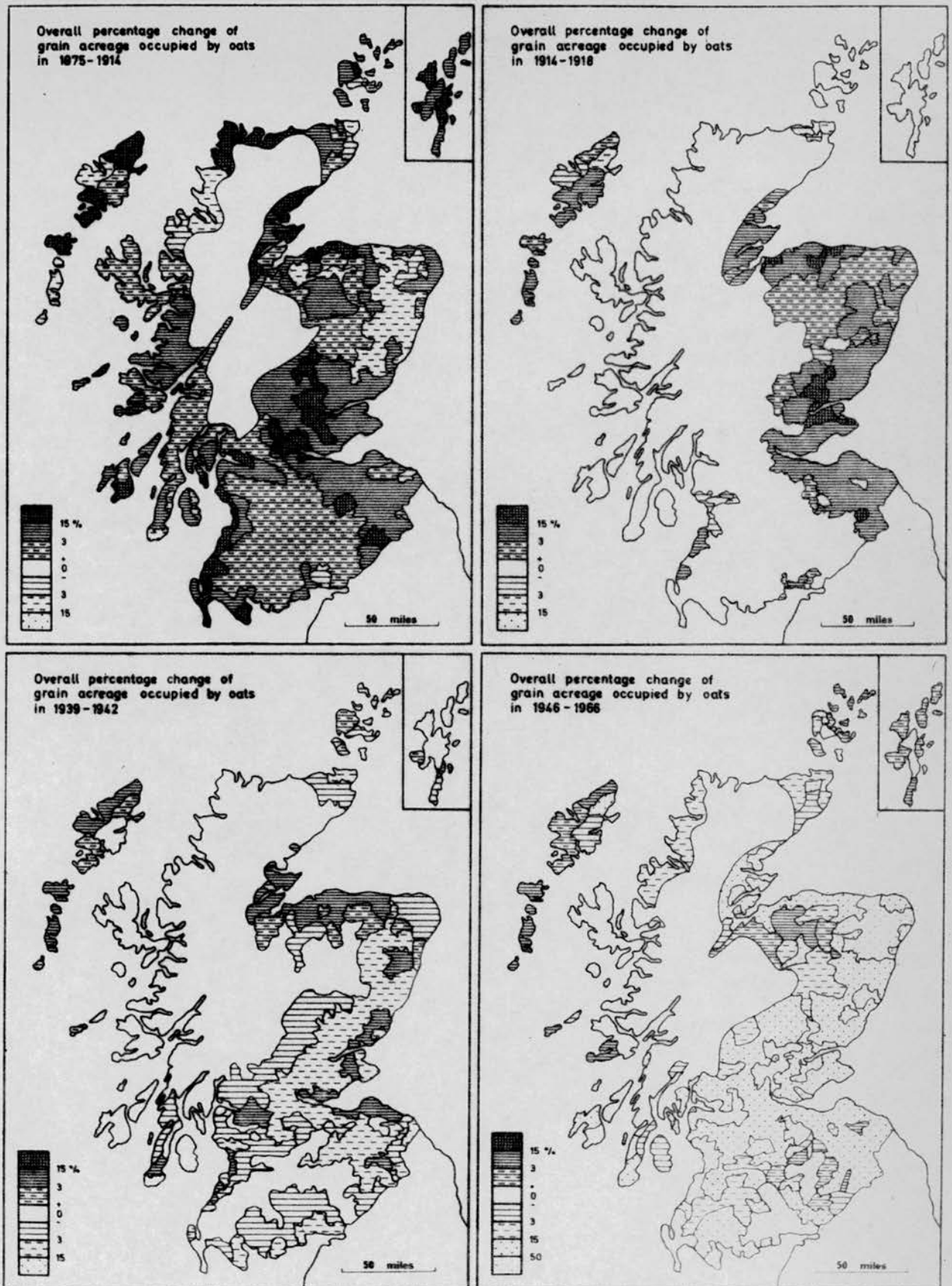


Figure 134

but by 1939-1942 the decrease in oats acreage was general except in the Moray Firth area and in parishes with very good arable land in the eastern lowlands and around the Clyde. The 1946-1966 map shows overwhelming change from oats. Large areas recorded a change exceeding 50 per cent. The period chosen is not a good one, and a better picture of the facts would have been gained by comparing change in 1956 and 1966. As with the other change maps of this series the period chosen was deliberate, to show the problems arising out of an unrealistic period gap.

Oats Overall Acreage Change Maps

The same problem arises in this series of maps. The comparison of oats acreages overall in 1866-1966 (Figure 135) does not reveal the significant change is really from 1956-1966. The map is offered because it is necessary to compare the beginning and the last year of the century of statistics. The isoline map 1866-1966 offers some additional patterns which could not be entered on the density map which already has 6 scale classes. The shaded map can be made to show the patterns revealed by the isoline map but at the expense of breaking up the pattern into patchy incoherence. The most important maps offered are those from 1946-1956 and 1956-1966. In the density map 1946-1956 (Figure 136) the acreage devoted to oats has increased particularly in the better grain growing areas. The largest loss of oats acreage is in the northeastern area of lowland Banff and Aberdeen and a second large one in lowland Dumfries. In 1956-1966 these two negative change concentrations had spread widely and the 1956-1966 isoline map gives the degree of change in a

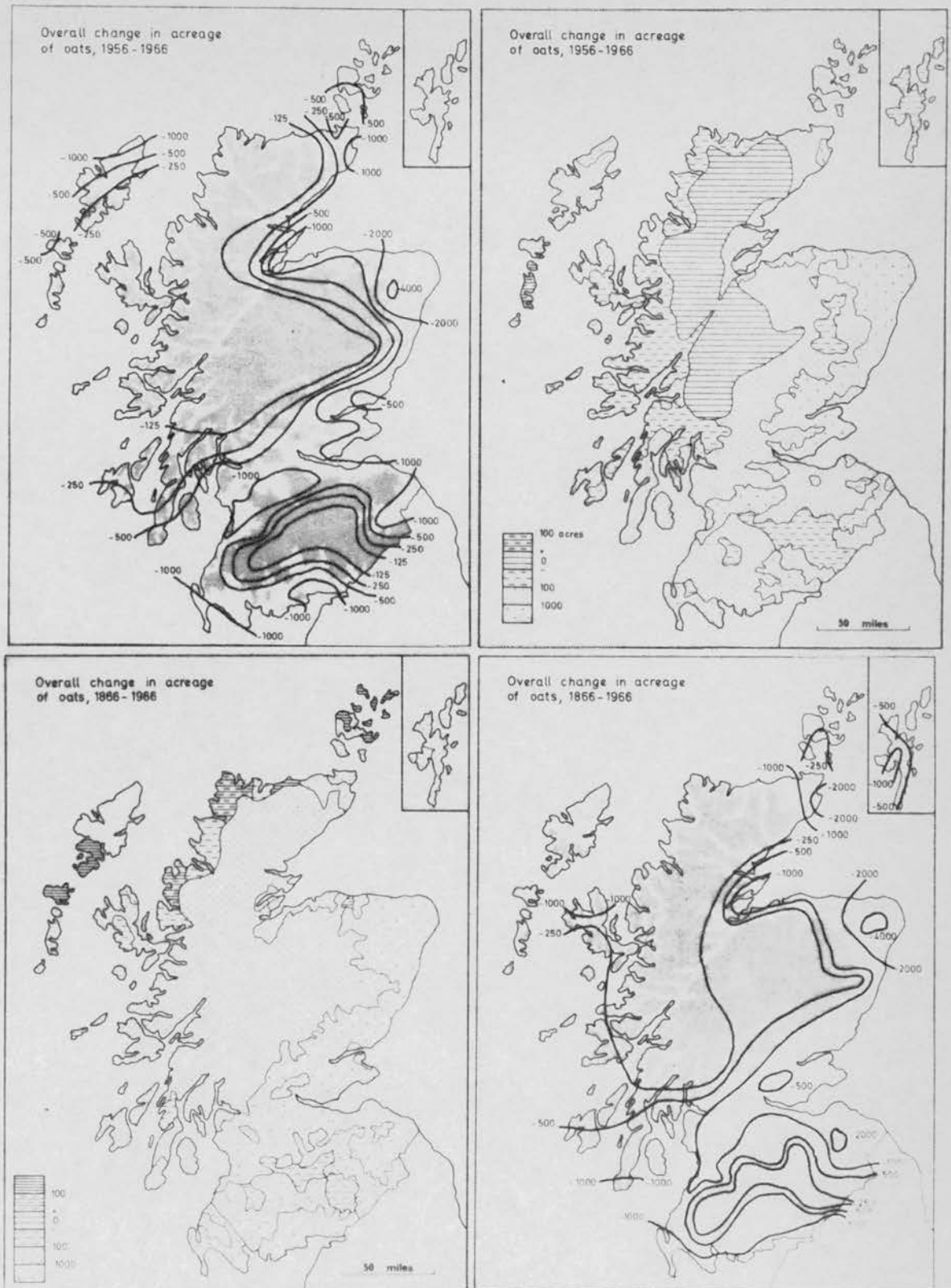


Figure 135

Overall change in acreage
of oats, 1946-1956

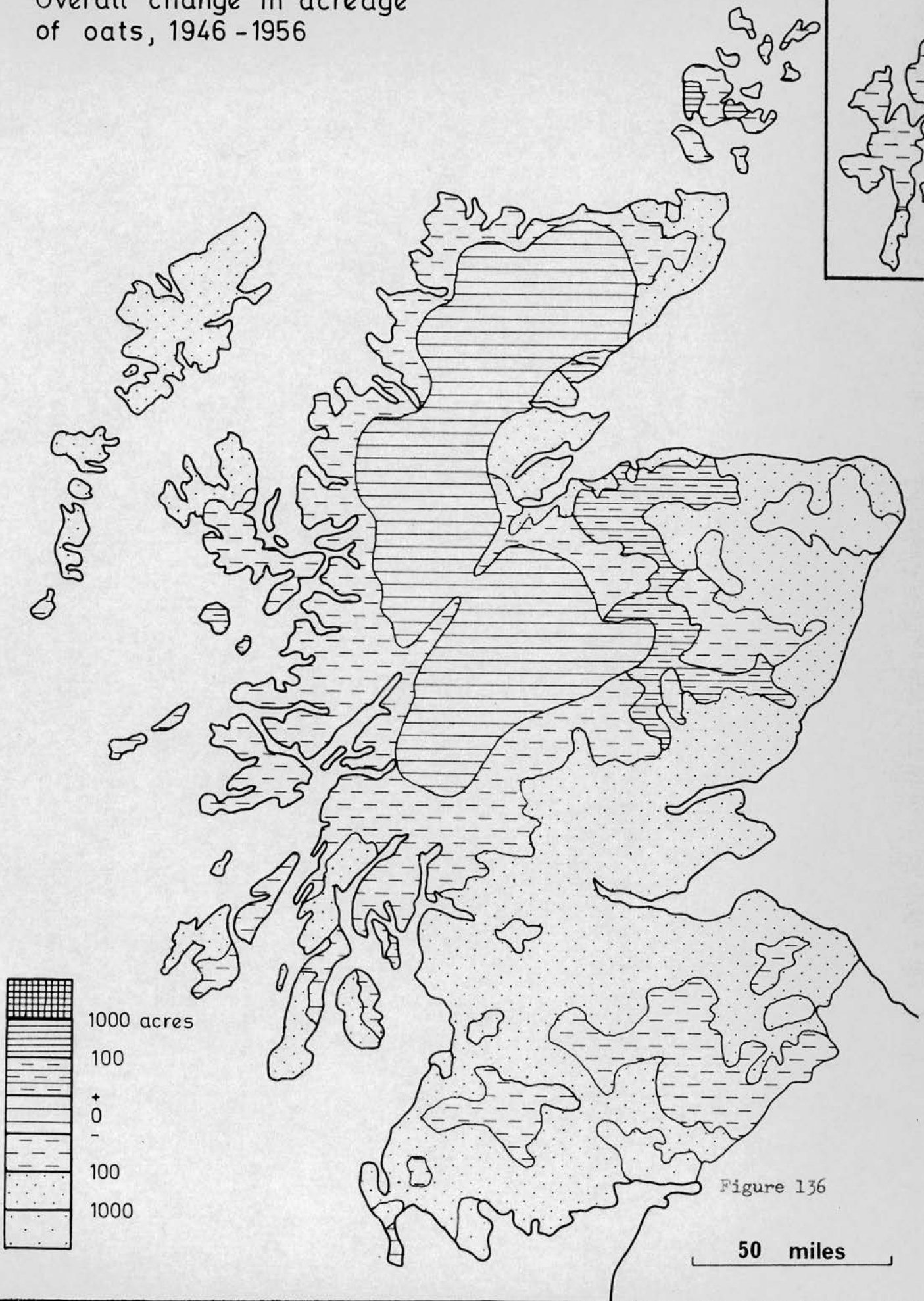


Figure 136

very simple straightforward way within the controls of the physiographic environment.

Equal Area Bar Graph Sections and Section Maps

The dominant role of oats in the greater part of Scotland is clearly shown on the graphs (Figures 76-81 on pages 186-191) and maps (Figures 84a, 84b and 84c on pages 196-198). For a large part of the country there has been no real alternative to the crop since it has a remarkable ability to withstand difficult conditions. The switch to barley at the expense of oat growing land is shown in 1966 in the section graphs but the change is not irreversible especially if the international demand for good quality feed grain continues at a high level. The excellent quality of Scottish oats could well establish a place in the markets on the continent to rival that of barley. At least oats growing is within the abilities of farmers in all parts of the country and in a wide range of good and bad years.

Regionally Based Bar Graph Maps

Oats acreages in the 8 sample years representing peak, trough and more average years are shown on one regionally based map (Figure 137). While oats are grown generally, the best yields are in Perth, Angus, Kincardine and East Lothian. This means that it takes more acres to produce the same results elsewhere. This difference in yielding ability needs very thorough research. It depends on many insufficiently known imponderables such as soils, drainage, slope, aspect, elevation and other physical factors. Research into new

Regional percentage share
of oats acreage and output
in selected years 1867-1965

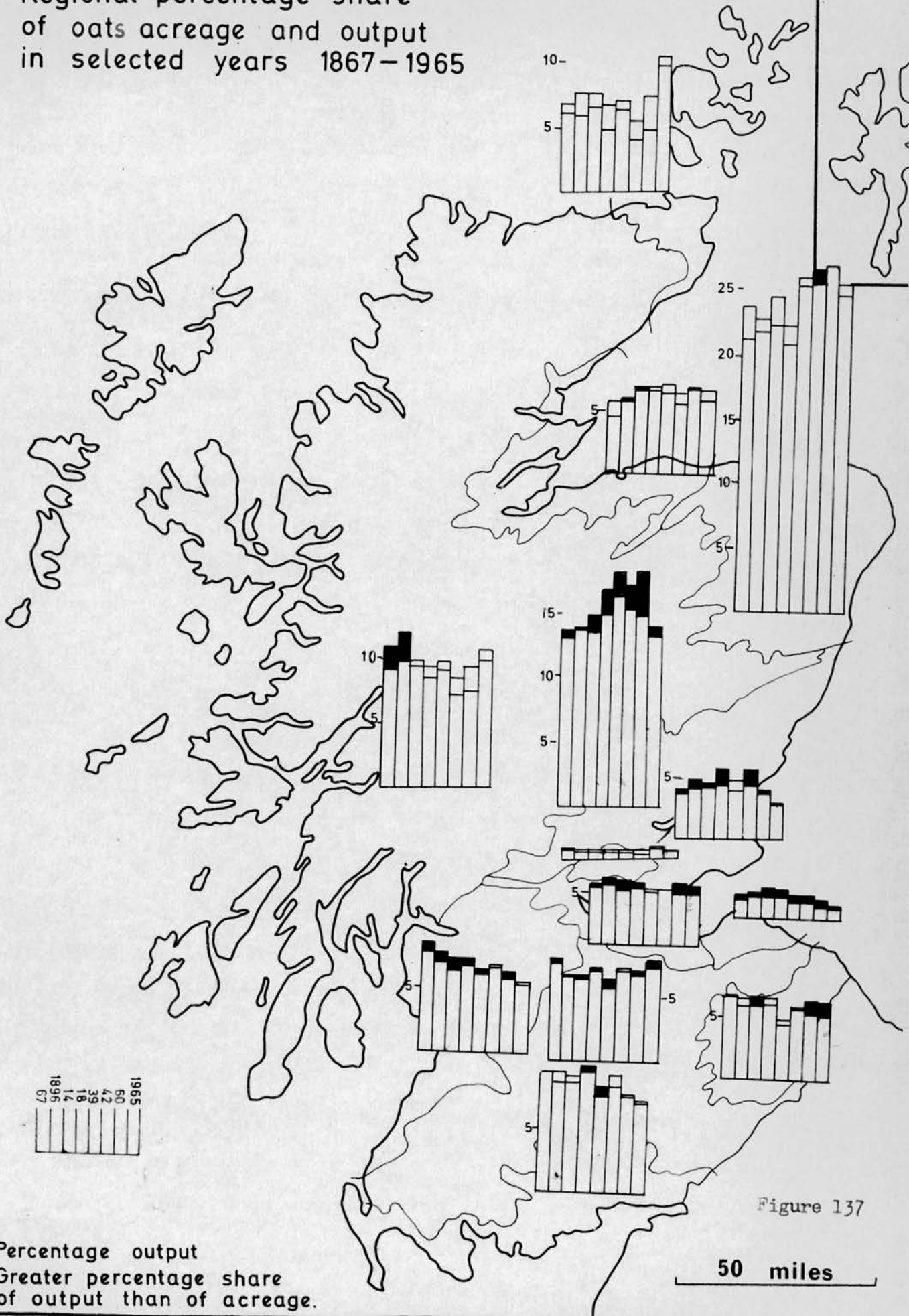


Figure 137

varieties of oats has produced excellent results in recent years but will do more when some of the contributing environmental factors are better understood. Yielder and Maelor oats have been recommended for uplands or late or wet districts with harvest difficulties, Blenda oats for bindering and Condor and Astor oats for combine harvesting.¹

Grain Order of Rank Maps and Graphs

The order of rank maps (Figures 118, 119, 120 and 121 on pages 259, 260, 261 and 262) provide another proof of the importance of oats cropping in the years 1866, 1918, 1943 and 1966. It was overwhelmingly the first and often the only grain crop until the last few years of the last decade to 1966. The places where alternatives were possible were strictly limited until the new varieties became widely known. Oats only, then oats-barley was the key category for a great part of the country. Oats, barley, then wheat became more important during the 1939-1945 war and the barley, oats, wheat pattern did not take over widely until after 1960. The graphs (Figures 102, 103, and 104, on pages 233-235) give details of changes in six important grain growing regions but they are really showing changes from oats. Other areas would have been shown giving oats more prominence if a representation of the old oats dominant pattern was desired.

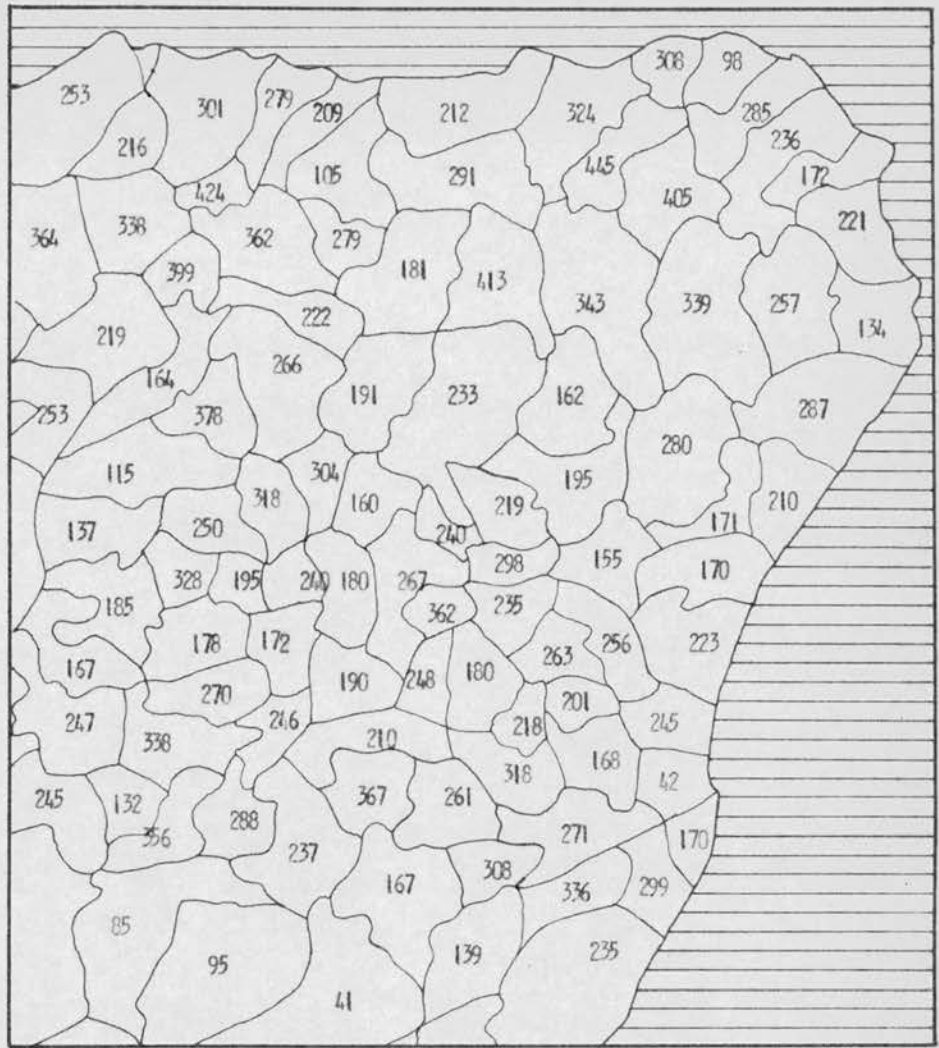
¹ Cereal Variety Recommendations 1968, Advisory Leaflet 45i, The West of Scotland Agricultural College, Glasgow, and Cereal Variety Recommendations 1968, Edinburgh and East of Scotland School of Agriculture. Both advisory leaflets were prepared in November 1967.

Raised Statistical Surface Maps

The two grain acreage raised statistical surface maps give a clear impression of the patterns discovered at the beginning and at the end of the 1866-1966 century. Oats form the firm base of Scottish grain farming and these maps (Figures 86 and 87, on pages 203 and 204) need little comment, since they have already been cited for total grain, wheat and barley patterns.

Unit Area Oats Acreage Stepped Frequency Surface Diagrams

Another way of showing the firm oats base in Scottish grain farming is well illustrated in the unit area diagram for arable Aberdeen (Figure 138) where 1 millimetre of vertical height represents 25 acres of oats. There is a platform-like quality about the diagram with some of the strongest patterns developed in the northeast. This aspect is not so general in the area south of the Forth (Figure 139). Grain cropping in lowland Berwick and Roxburgh was strongly based on oats in 1966 but the same cannot be said for East Lothian or Midlothian. Ideally these diagrams would be prepared for key years representing the ups and downs of grain growing and the grain acreage unit area number pattern equivalent employed to fill in all of the years between. At any rate, the characteristic patterns of oat growing show a uniformity which is not possible using the parish base with all of its problems of different sizes. The accident of size in a parish should not provide all map and diagram representation thereafter with peaks in that area just because a neighbouring parish is very small and reports smaller quantities measured.



1 unit = 5 mm² or 14.7 sq. Kms

(1:625000)

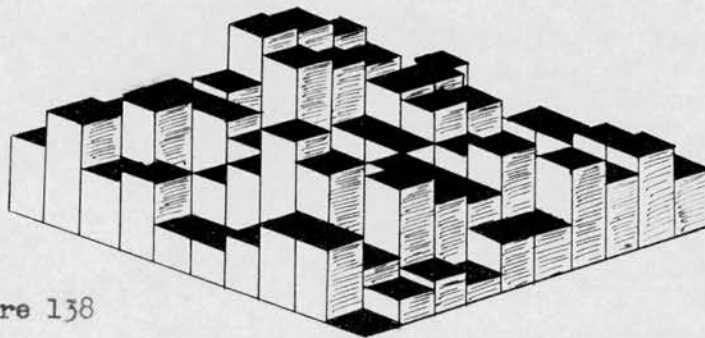
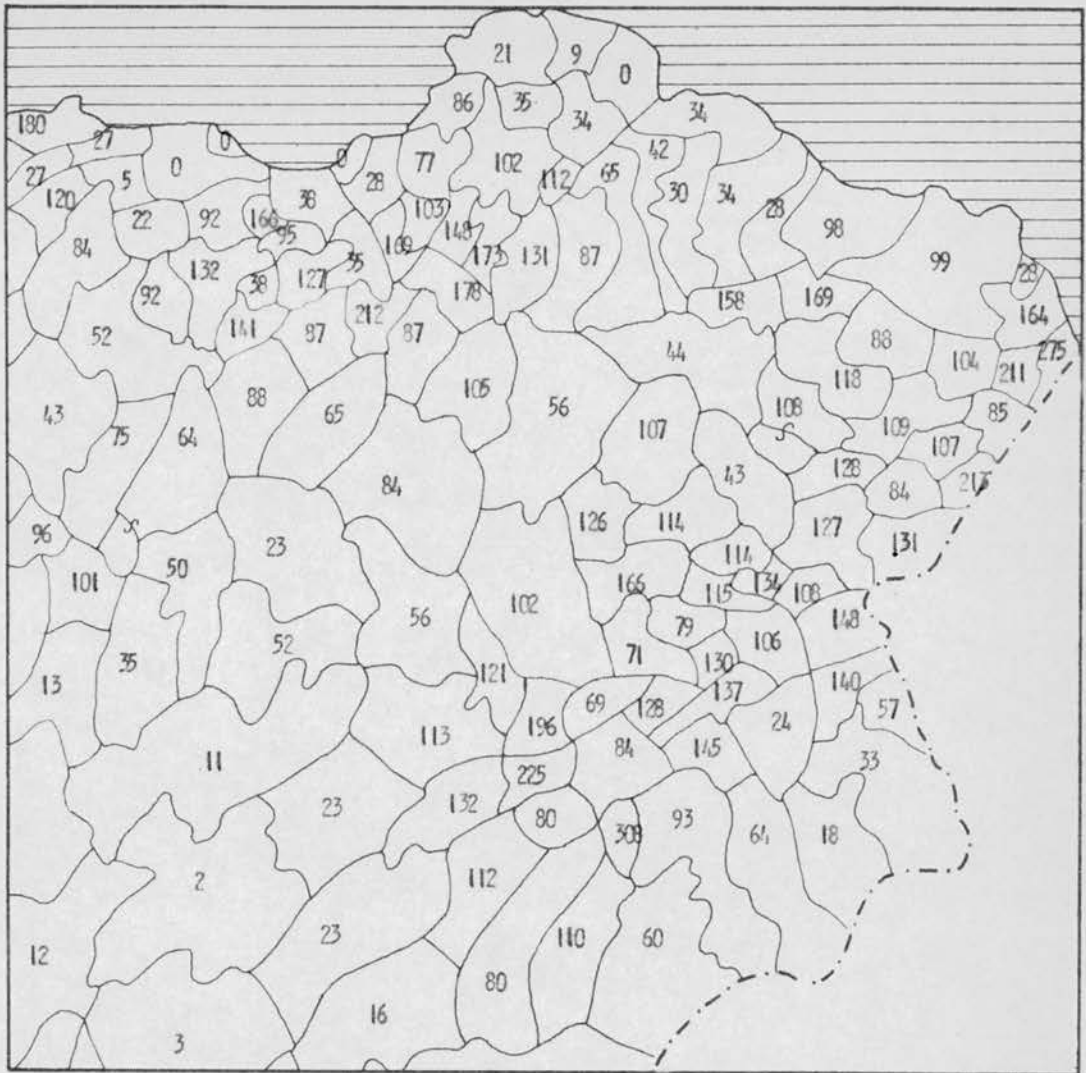


Figure 138

Vertical scale- 1mm. : 25 acres

Acres of oats per unit area in 1966



1 unit = 5 mm² or 14.7 sq.Kms

(1:625000)

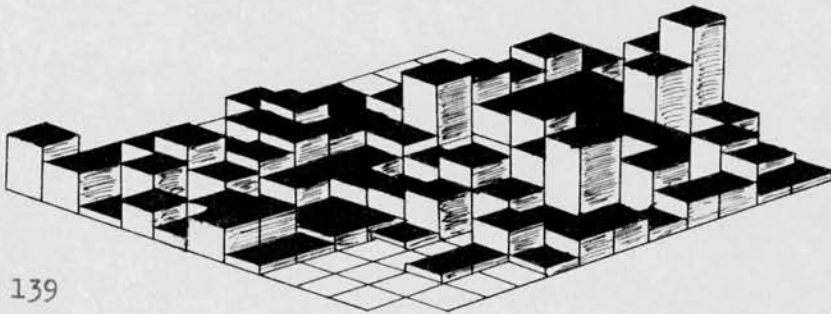


Figure 139

Vertical scale- 1 mm. : 25 acres

Acreage of oats per unit area in 1966

The Changing Pattern of Rye Distribution

Rye has never been an important grain in Scotland. It is not as versatile as a feed grain and it is not so popular for human consumption. During the 1939-1945 war the need for an increased supply of human food led to acreage payments being offered for wheat, rye and potatoes and a compulsory cropping notice was imposed.¹ The result was a spectacular though brief, increase in rye acreage. During most of the century when rye was reported separately, part of the acreages were planted to provide green fodder or grazing and were not intended for threshing. From 1939 to 1944 inclusive, green fodder is mentioned in the census reports as included in the acreage totals for rye. It appeared that this had been the case for the years before but during this period the statement was explicit. From 1945 the category rye-for-threshing was used and in 1961 and thereafter rye for threshing, green fodder or silage was put in a common category with mashlum, beans, vetches and tares.

In Scotland as a whole, rye accounted for 7,066 acres of grain in 1867 and increased to a high of 12,106 acres in 1873. From that year to 1926, rye acreages ranged between 4,800 and 10,000 acres but were generally over 6,000 acres. After 1926 acreages fell steadily from 3,900 to a low of 1,130 acres in 1939. The increase during the war reached its height in 1943 with 11,049 acres but by 1952 the total had fallen to less than 3,000 acres and by 1957 to less than 1,000 acres. The rye crop acreage totals were

¹. See pages 247-8 in Symon, J., *Scottish Farming*, Oliver and Boyd, Edinburgh 1959.

frequently 10 per cent of those for wheat until 1925 and generally 5 or 6 per cent or less thereafter.

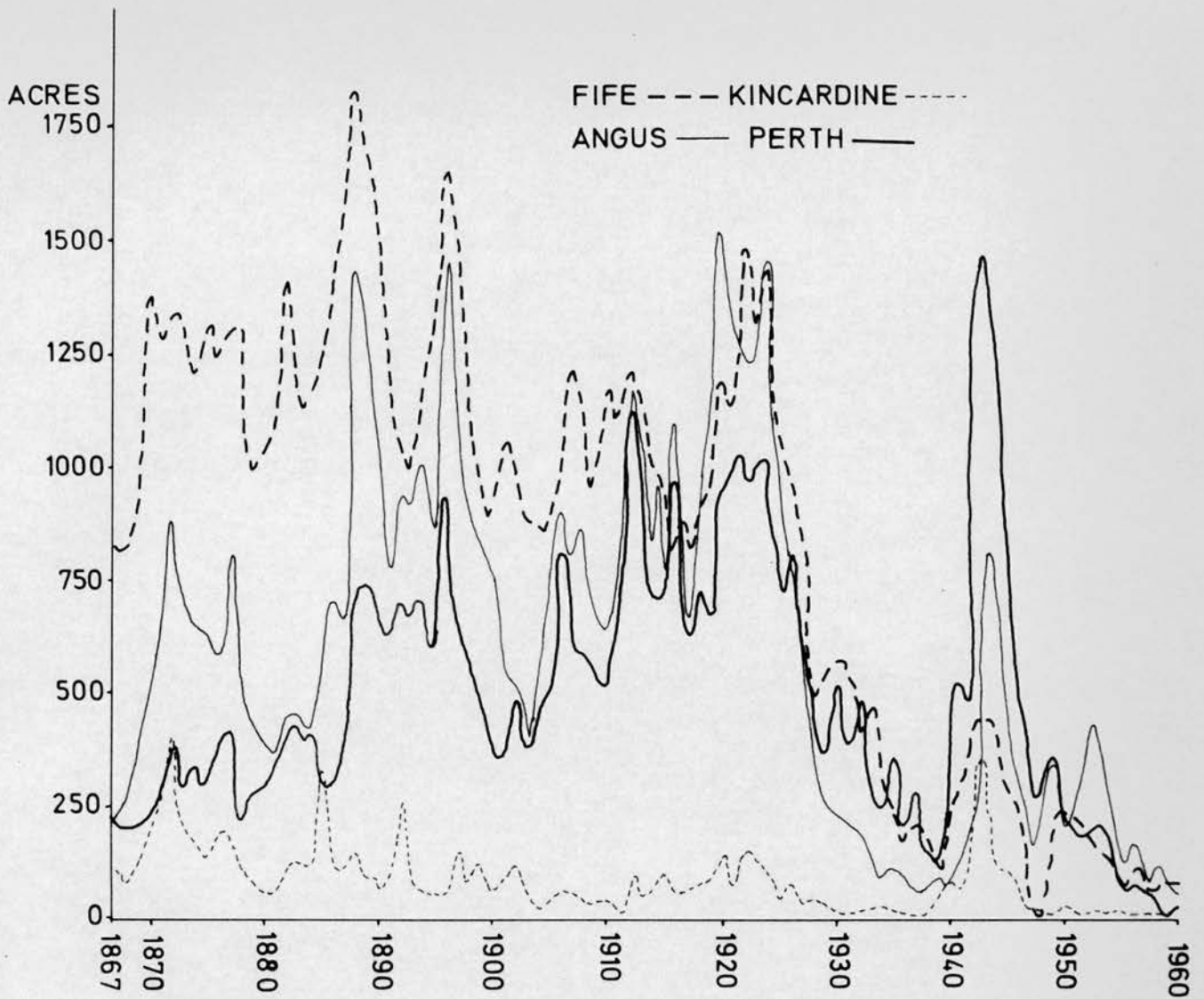
The eleven counties where rye has had some importance over the period 1867-1960 have been graphed on three regional graphs (Figures 140, 141 and 142) and are presented in the following table in summary form for the century and roughly half-centuries.

RYE ACREAGES

| County | 1867-1960 | 1867-1914 | 1915-1960 |
|--------------------------------|-----------|-----------|-----------|
| Aberdeen | 26,722 | 21,630 | 5,092 |
| Banff | 8,666 | 7,562 | 1,104 |
| Moray | 54,088 | 41,939 | 12,149 |
| Nairn | 12,726 | 11,402 | 1,324 |
| Inverness ¹ | 82,131 | 38,295 | 43,836 |
| Ross and Cromarty ² | 49,989 | 41,445 | 8,544 |
| Argyll ³ | 36,639 | 24,762 | 11,877 |
| Fife | 80,247 | 56,387 | 23,860 |
| Angus | 55,418 | 34,748 | 20,670 |
| Kincardine | 7,591 | 5,287 | 2,304 |
| Perth | 43,947 | 22,710 | 21,237 |

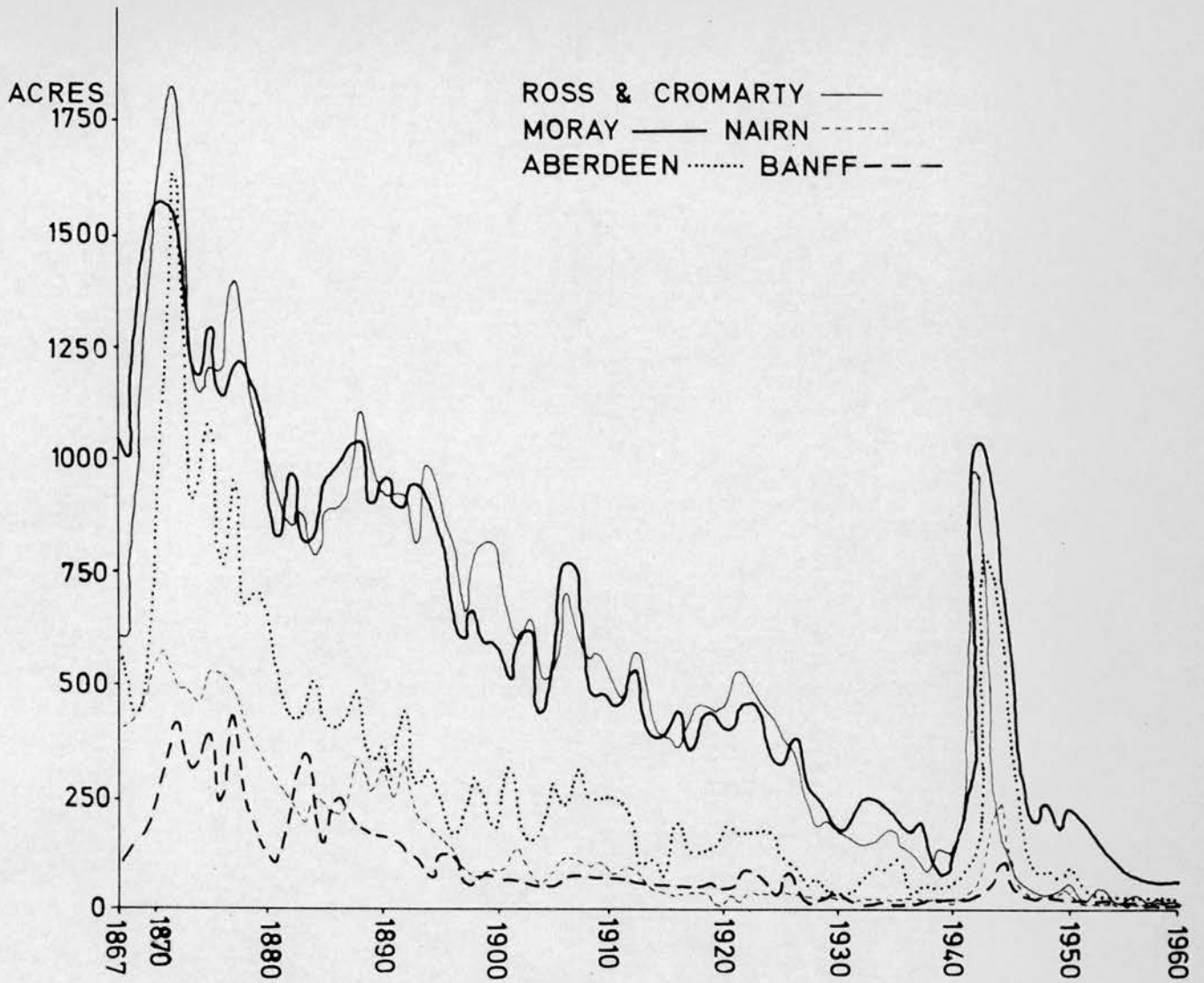
The first six counties reported nearly 44 per cent of the rye acreage in the years 1867-1960 and the last four 36 per cent. In the period 1915-1960 the percentages for the same order of groups was 42 and 42. The county of Argyll (but mainly Mull) accounted for 7 per cent and another 7 per cent was contributed for the southwestern counties from Dunbarton to Dumfries and 4 per cent for the Forth region south to Berwick and Roxburgh over 1867-1960. Rye was never important south of a line drawn south of Argyll, Perth, Kinross and Fife and compared to other grain only a minor crop north of that line.

¹The great majority of the rye acres were reported from Harris and North and South Uist
² " " " " Easter Ross
³ " " " " Mull



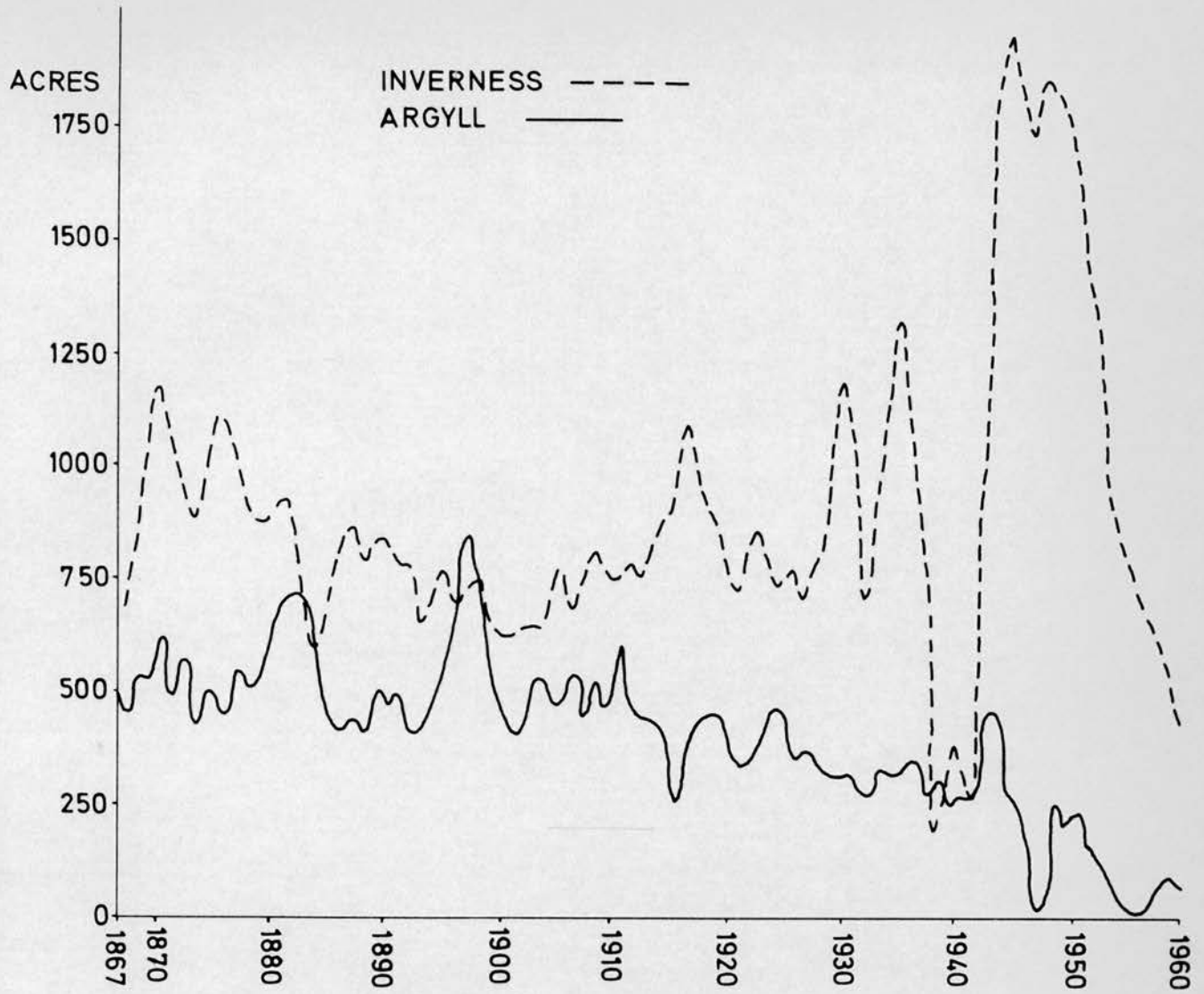
Rye acreage, 1867-1960, in counties where it has been of importance

Figure 140



Rye acreage, 1867–1960, in counties where it has been of importance

Figure 141



Rye acreage, 1867-1960, in counties where it has been of importance

Figure 142

The graphs give a detailed picture from 1867-1966 in the eleven counties. The curves of the graphed acreages match well regionally but less well over the total, so that Inverness and Argyll were shown separately as having more in common with each other and less in common with the other 9 counties. The affect of the compulsory cropping notice during the 1939-1945 war adds a striking pattern to the graphed acreage lines.

The Position of Mixed Grain in the Distribution Patterns

No illustrative material is offered for mixed grain. Acreage statistics for mixed grain were reported from 1918. Working parish maps were used to plot the acreages every five years and four of them 15 years apart are referred to here as a sample representation of the situation. Mixed grain cropping is usually resorted to when the yield is intended for on-the-farm consumption by livestock and it may also provide a cover crop for a new sowing of grass and other green fodder mixtures. Usually the common combination of oats and barley is grown, if the sowing season has been delayed. If the ground is overly damp, cold and the weather backward, with sowing already behind schedule, a mixture of grain may be sown, in the hope that one or the other or both of the grains will do better than expected. Mixed oats and barley may be fed to most farm livestock, whole or ground.

In 1921 when a rough working parish map was plotted with actual mixed grain acres, it was found that North Uist with 292 acres accounted for nearly 75 per cent of

the acres reported for the whole of Scotland, North of Angus there were only 15 parishes reporting a total of 80 acres of which 25 acres was in South Uist. South of Kincardine, in the Firths of Tay and Forth regions, 31 parishes reported mixed grain of which only 6 were more than 15 acres. Besides this, there were 14 scattered parishes in the rest of the south with from 1 to 19 acres of mixed grain.

In 1936 the main rye growing was still in North Uist with 321 acres and South Uist with 1,051 acres. Elsewhere the amounts were almost identical to 1921 and other years earlier and in between, except for 47 acres and 20 acres in Smailholm and Merton in Roxburgh and Berwick. The year 1951 represents a much more concentrated picture and was chosen as an example of a relatively high year. More than 300 parishes reported some mixed grain. North Uist had 271, South Uist 168, Errol, Perth 89, Rerrick, Kirkcudbright 90, Turriff, Aberdeen 83, Dunfermline, Fife 88, Annan and Cummertrees, Dumfries 58 and 65 and Kilmarnock, Ayr 85 acres. Elsewhere the acreages were from 1-25 usually, with most parishes reporting a very few acres.

In 1966 North Uist reported 119 and South Uist 300 acres out of 133 parishes having some mixed grain. There was little pattern to the distribution except a certain general concentration in Ayr, Lanark and Dumfries, with the bigger acreages reported in upland parishes usually around Biggar. The total acreage did not exceed 1,000 acres so that the crop cannot be said to be significant out of the total grain acreage of 1,127,000 in Scotland that year.

Full-time Labour and Grain Distribution Patterns

One of the most significant factors helping to explain the recent increasing emphasis on grain cash crops in Scotland, is the steadily declining pool of farm labour. Grain farming can be carried on with much less human labour than such labour-intensive crops as potatoes, sugar beet, cabbage and the like.¹ Many farmers find that once their present labour force goes into retirement in the early 1970's that there are no younger men in sight to replace them.²

Expensive mechanized equipment takes the place of hired labour but if the whole range of equipment is installed the grain is rapidly dried, safely stored and sold at the premium prices for seed grain or high quality malting barley or excellent feed grain. The outlay in expenditure seems justified especially since hired human labour is so difficult to obtain. The increasing concentration on grain growing has arisen naturally from a long experience with the crop and the climate helps to grow exceptionally good grain crops. The new varieties have overcome many of the early problems to do with plant diseases, pests, lodging of grain, resistance to drought and dampness and so on. However, the investment in expensive equipment fixes the pattern of grain farming more firmly and destroys some of the versatility of the Scottish farmer to meet changing

1. An estimated 3.5-4.5 man days per acre are required to produce wheat, barley, rye, oats and mixed grain, and 20 for potatoes, 17 for cabbage, 21 for mangolds and fodder beet etc. See Coppock, J. T., Regional Differences in Labour Requirements in England and Wales, Farm Economist 10(9)1964 pp 386-390.

2. From an address given by J. Stevenson, Luffness Mains, Aberlady, East Lothian, to visiting University of Edinburgh students November 5, 1966.

demands on his products. Chambers and Mingay outline the idea of "convertible agriculture"¹ in an early period when grain prices fell (1700-1760) and land was quickly turned to grass, turnips and other hoed crops and livestock numbers increased or held over for sale at a more mature finish.

"From 1875 - when the full extent of competition from overseas food production was first felt- up to 1940, British Agriculture, apart from a short spell of prosperity in the First World War, was a depressed industry. The demand for labour contracted sharply in the last quarter of the nineteenth century, and wages fell. Arable land was laid to pasture, while further progress in the use of machinery reduced employment. Some improvement occurred as prices rose in the early years of the twentieth century, but in the inter-war years the arable areas continued to shrink and power machinery replaced horse-drawn implements. The total volume of agricultural production remained below the level of 1870 until 1940."² Up to the 1939-1945 war the agricultural labour force continued to decline in absolute numbers, while the total labour force continued to grow rapidly. Since 1945 the decline especially in Scotland, has been severe, particularly in the highland-uplands and

1. See pages 4 and 40 in Chambers, J.D., and Mingay, G.E., *Agricultural Revolution 1750-1880*, Batsford, London, 1966.

2. See page 47 in the I.L.O publication, *Why Labour Leaves the Land, A Comparative Study of the Movement of Labour out of Agriculture*, International Labour Office, Studies and Reports, New Series, No. 59, Geneva, 1960, 229 pages.

islands, "Considering that the tillage acreage is much bigger than 1939, the farm labour situation is serious and a drop in farm production has only been arrested by the adoption of a high degree of mechanization on the low ground and stock rearing farms. With a small recruitment of young farm workers the average age of farm staffs is increasing.¹

The problem of the scarcity of labour has had a good deal of coverage in reports, papers and books in recent years. The chief advantages of automation is that "Scarce labour can be conserved for those tasks requiring the greatest degree of human judgement. The limits of control attainable under human guidance can be exceeded by mechanisms which work faster, more accurately and without fatigue, providing greater efficiency and better quality of product."² Pilotless tractor and other field equipment have been developed and the fact that a large number of Scottish farmers attended the National Power Farming Conference at Harrogate in 1967 is some evidence of the problems facing them. A position has been reached in British farming where labour was not just being "shed" it was "a case of personnel fleeing the industry."³

1. See pages 174-175 in Chapter 7 on Agriculture, by Buckpitt, W.A., Hughes, D.A., and Wallace, J.G., in Ragg, J.M., and Fitty, D.W., The Soils of the Country round Haddington and Eyemouth, Memoir of the Soil Survey of Great Britain, Department of Agriculture and Fisheries for Scotland, HMSO, Edinburgh 1967.

2. Views expressed on page 3 by Cox, S.W.R., Automation Down to Earth, The 16th National Power Farming Conference, Harrogate, February 2, 1967.

3. Urquhart, R., Farm Workers "Fleeing the Industry", The Scotsman January 11, 1967 reporting on an address by J. Minto of Biggar to the council of the National Farmers Union of Scotland in Edinburgh, January 10, 1967.

The situation for farmers in the rougher hill areas is especially difficult because automated mechanized equipment is not justified where fields are small and scattered, hilly and with added problems of drainage, fertilizing and harvesting. In earlier centuries a larger rural population in these regions cultivated more land to live at subsistence levels. Today much of the more marginal grain land has been returned to grazing and only the best valley bottom land still supports cultivated crops. For many years the Agriculture Wages Board have tried to ensure basic salary rates in the farming industry and the Corn Production Act 1917 was an early manifestation of the expressed concern. In 1967 a report to parliament suggested that the national run-down of the agricultural labour force forecast under the National Plan to be 125,000 farm workers by 1970 might be 20,000 too low.¹ The result of this exodus is to force farmers who have land suitable for mechanization, to invest heavily in equipment and fix their cropping patterns to crops for which the equipment is designed to handle.² The large amount of capital which has been invested in machinery has had the effect of keeping the acreage of tillage at a high level in order to employ the machines to the fullest extent.²

1. See Amey, L., Manpower Exodus May Rise, Agricultural Topics, The Times, October 9, 1967.

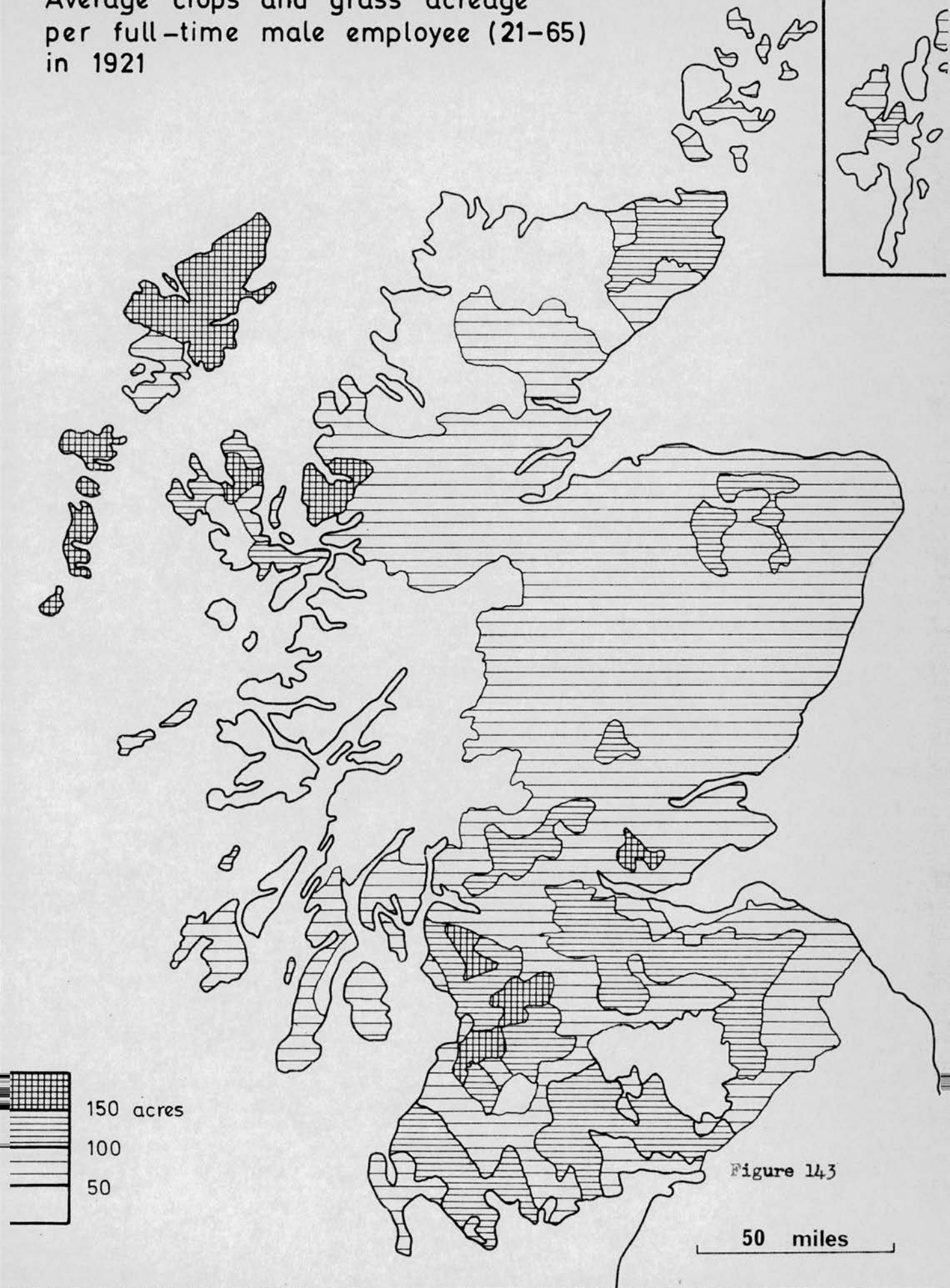
2. From Page 130 by Buckpitt, W.A. and Corner, H.H., in Ragg, J.M., The Soils of the Country around Kelso and Lauder, Memoirs of the Soil Survey of Great Britain, Department of Agriculture and Fisheries for Scotland, HMSO, Edinburgh 1960.

Density Shaded Maps Relating Labour to Land Use

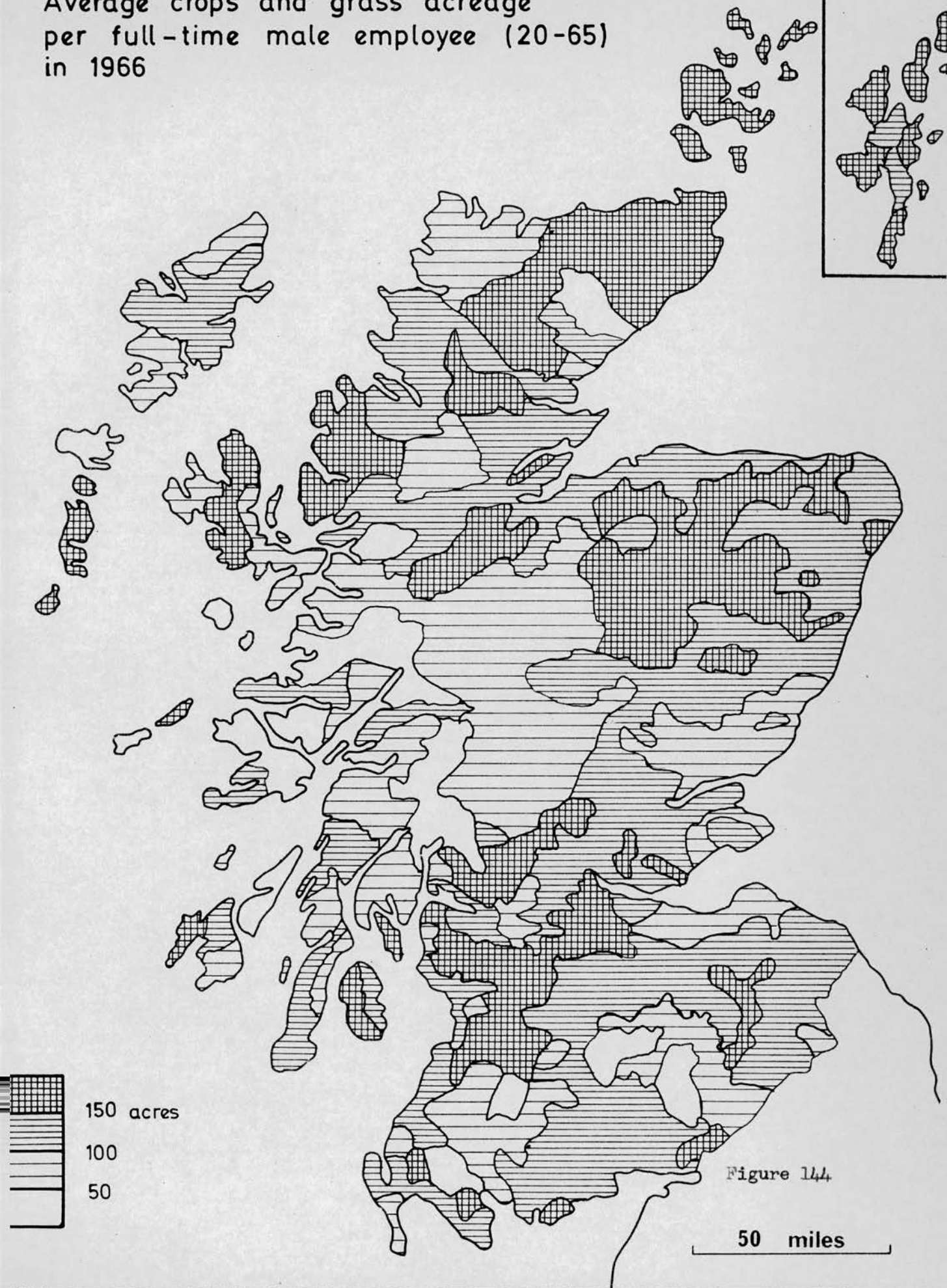
Two maps are offered to show the changing patterns in two sample years 1921 and 1966 (Figures 143 and 144). Labour statistics were begun in 1921 to meet the needs of the Corn Production Act 1917. The Act established minimum prices for wheat and oats 1917-1922 but also was concerned with minimum wages for agricultural labour. The statistics for numbers of full-time and regular part-time labour have been gathered annually since 1921. The number of acres of crops and grass per full-time male employee (aged 21-65) is plotted by parishes in the 1921 map and for the same ratio in 1966 except that the age of the labour employed is from 20-65 years. The farmer (owner or operator) is not included. Maps were prepared expressing the ratio for every five years since 1921 but the ones produced here are representative samples. The years between are given sample coverage in line graphs by parishes.

In 1921 the areas with full-time male labour for 50 acres or less of crops and grassland were in the highland-uplands where crops and grass totals are small and the main purpose of employing labour was for help in the livestock raising industry. In the greater part of the country there was one hired man for 51 to 100 acres, more generally in the upper end of the range. In 1966 the situation had changed considerably and only in the better arable areas and in parts of the highland-upland area was there one man available for 51 to 100 acres of crops and grass. In much of Scotland the ratios were much higher. In Aberdeen, Ayr,

Average crops and grass acreage
per full-time male employee (21-65)
in 1921



Average crops and grass acreage
per full-time male employee (20-65)
in 1966



Lanark and West Lothian the ratios were generally from 120 to 200 acres per man hired.

The maps give another dimension of the problem of the large scale contraction in cropping patterns in the highland-uplands and islands. In the crofting parishes and counties there are few, if any, employees outside of the family and few inside the age limits reported. Consequently the patterns in such areas are misleading and the crofting operator relationship to crops and grass acreage would have been a preferable ratio if statistics had been available.

Line Graphs 1921-1966

Twelve parish based line graphs (Figure 145) give a depth of time element to the patterns. The relationship of full-time labour aged 21-65 to crops and grass acreage in 1921-1960 and the relationship of those aged 20-65 from 1961-1966 has been plotted in five year intervals. The parishes were chosen to represent counties and cropping patterns over the entire country. Thurso, Killearn, New Deer, Inverarity, Kirkpatrick-Fleming and Kilmacolm parishes show an increased pool of labour absorbed in 1931 during the depression years and the ratios were low. Others such as Kingarth, Haddington and St. Ninian's show a larger pool of labour absorbed during the 1939-1945 war years in the year 1941. All show the decrease of full-time labour by 1966. The graphs and the maps do not show that in 1966 a great many farms per parish were being operated entirely without employed male help on a full-time basis. Some of these may secure part-time help in season.

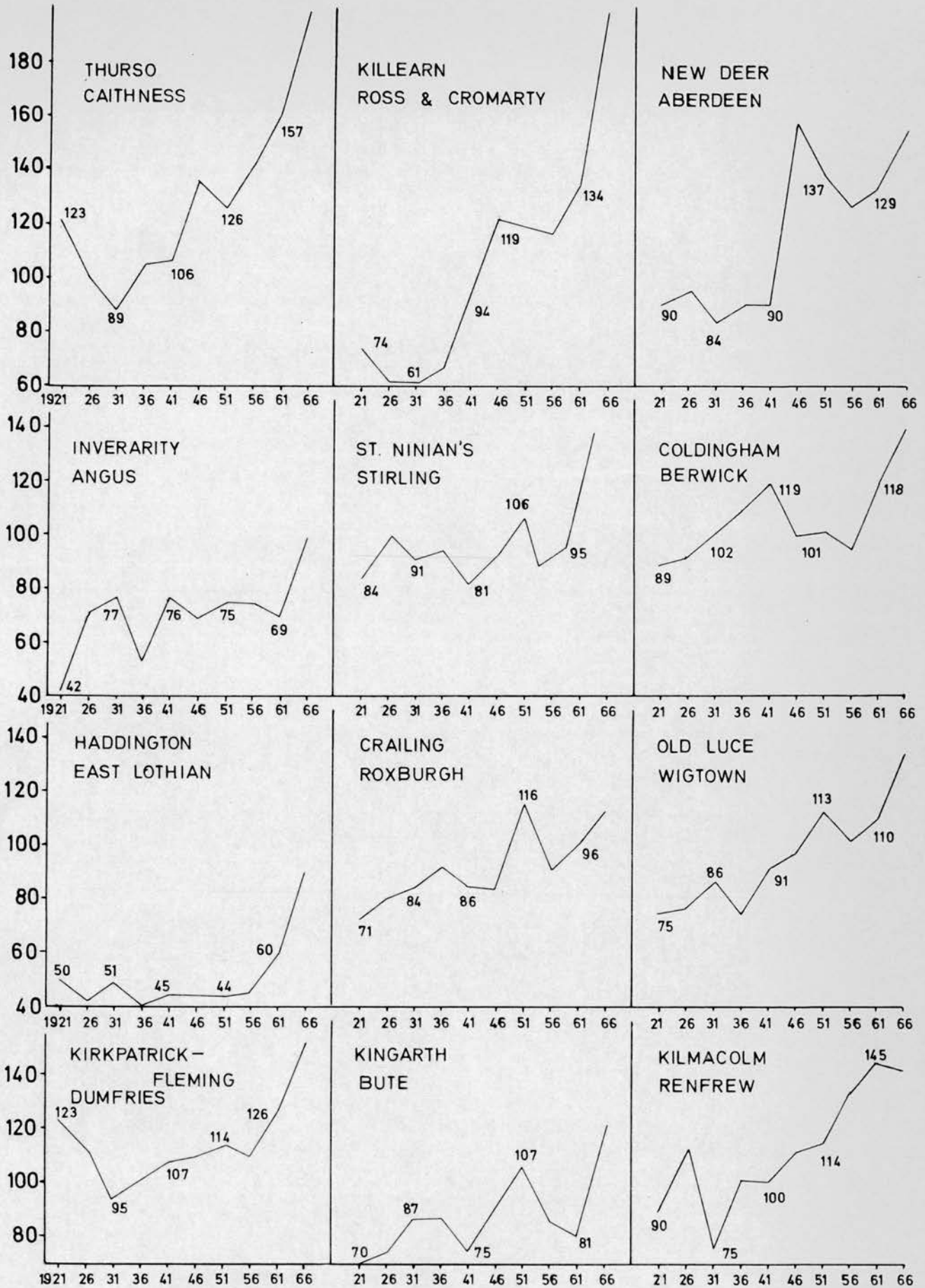


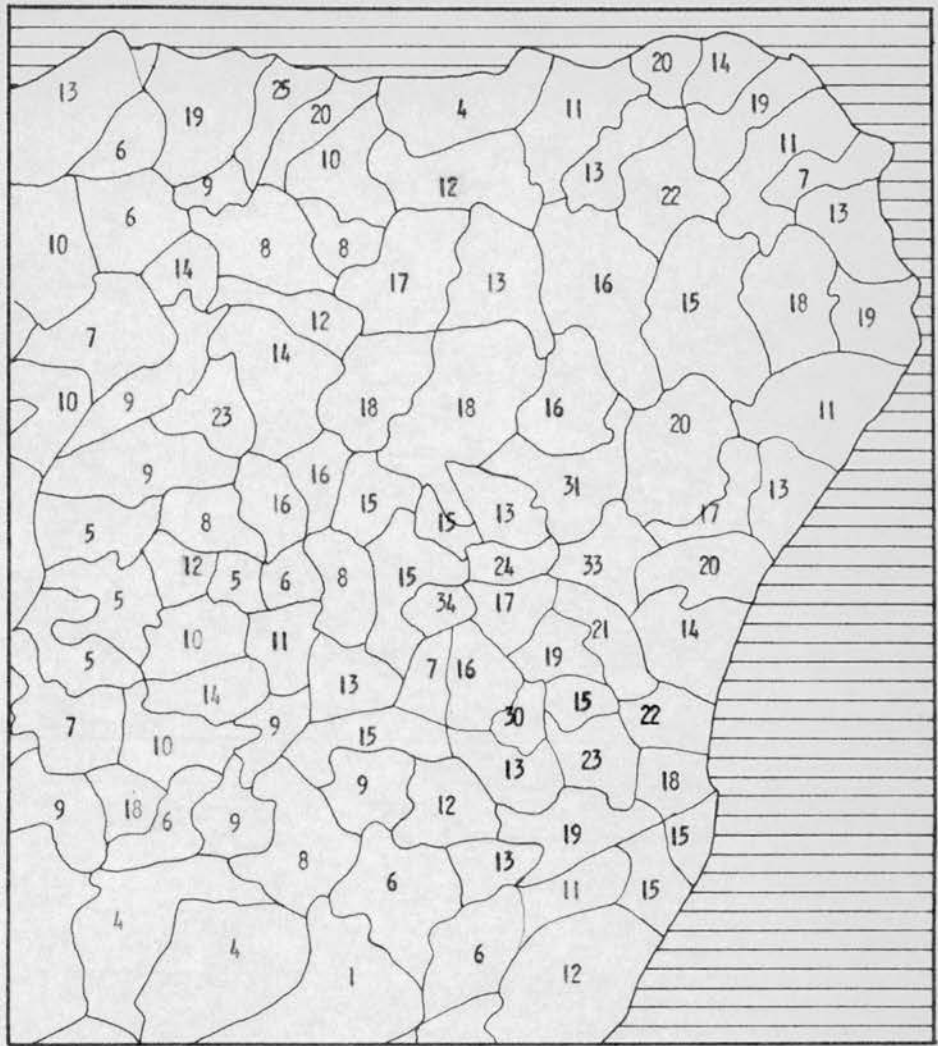
Figure 145

Unit Area Diagrams

The two unit area diagrams with accompanying key maps show the number of full-time male help employed in the Aberdeen area and south of the Forth (Figures 146 and 147), and offer a useful perspective. Less men are available and less are needed in the rougher hill parishes. Considerably more help is required in the highly arable parishes of northern coastal East Lothian where labour-intensive crops are grown, or farms may be forced to turn to grain. The unit area diagrams for the numbers of holdings per unit area offer a useful comparison (Figures 148 and 149). It is apparent that in some of the parishes of eastern Berwick and central Aberdeen that many farms are operated without the services of full-time hired labour. When these parishes are examined for grain patterns (Figures 88 and 89 on pages 206 and 207) they are found to be characteristically higher per unit area than neighbouring parishes. The diagrams below give pictorial emphasis to the relationship.

Summary

The decrease in labour availability has hastened the concentration of increased grain acreages within the land better suited for it as well as on land which may be used to grow other crops. Loss of labour has gone some way in encouraging greater specialization in grain cropping as a labour extensive activity where mechanization offers some relief. Where short-term cash crops are required from good arable land mechanization is often the only answer if a crop is to be grown at all. The result may be a hardening



1 unit = 5 mm² or 14.7 sq. Kms

(1:625000)

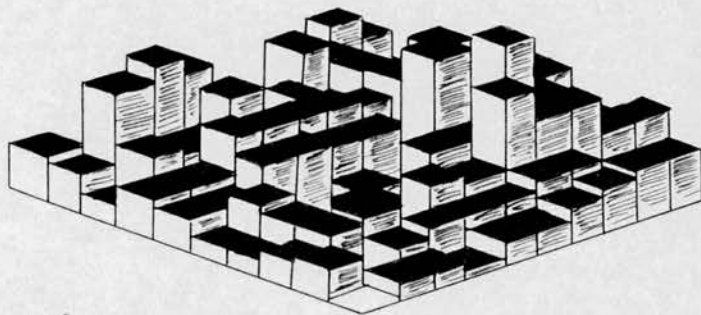
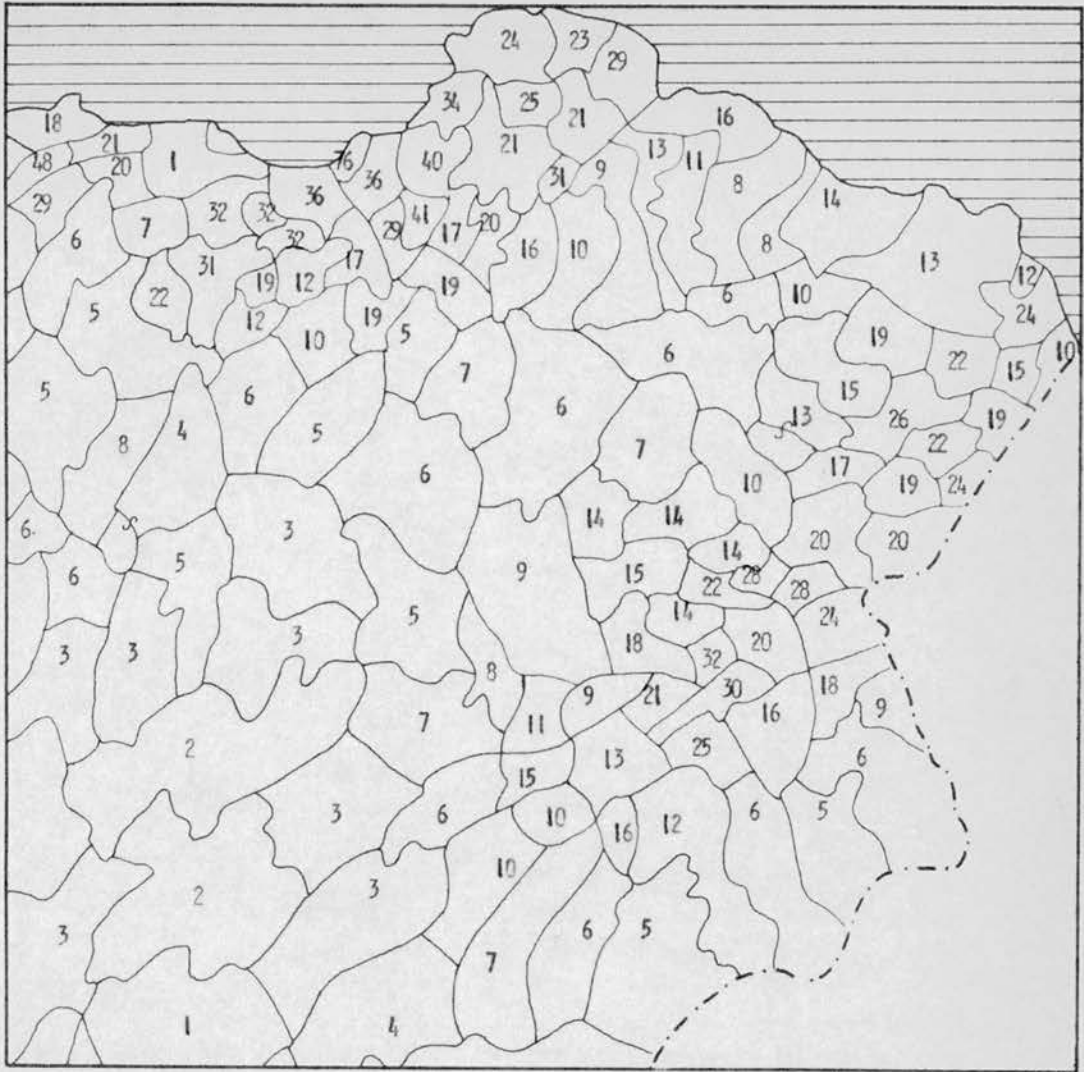


Figure 146

Vertical scale - 1 mm. : 2 men

Number of fulltime males (20-65) employed
per unit area in 1966



1 unit = 5 mm² or 14.7 sq. Kms

(1:625000)

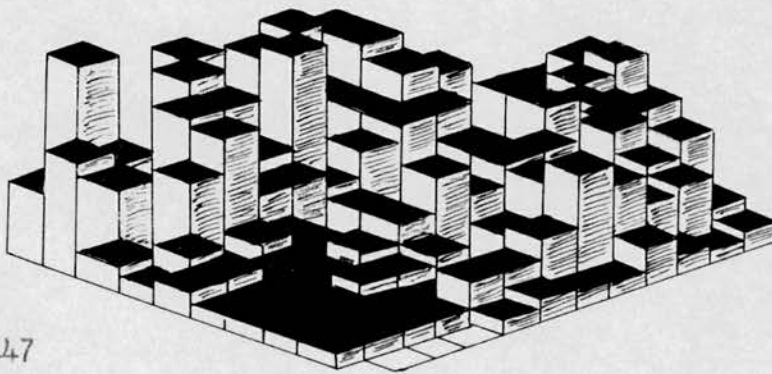
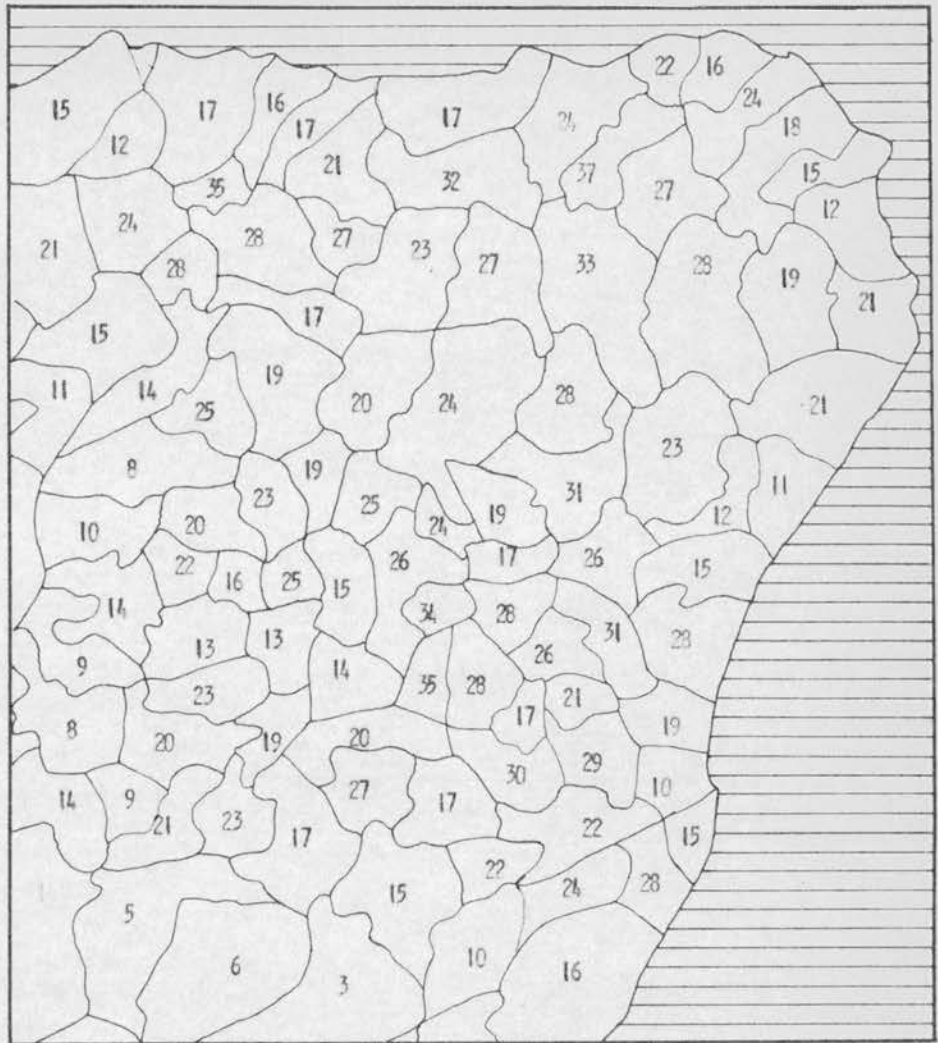


Figure 147

Vertical scale - 1mm. : 2 men

Number of fulltime males (20-65) per unit area,
in 1966



1 unit = 5 mm² or 14.7 sq. Kms

(1:625000)

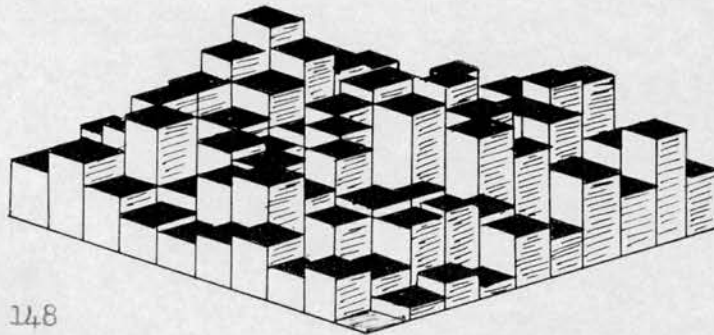
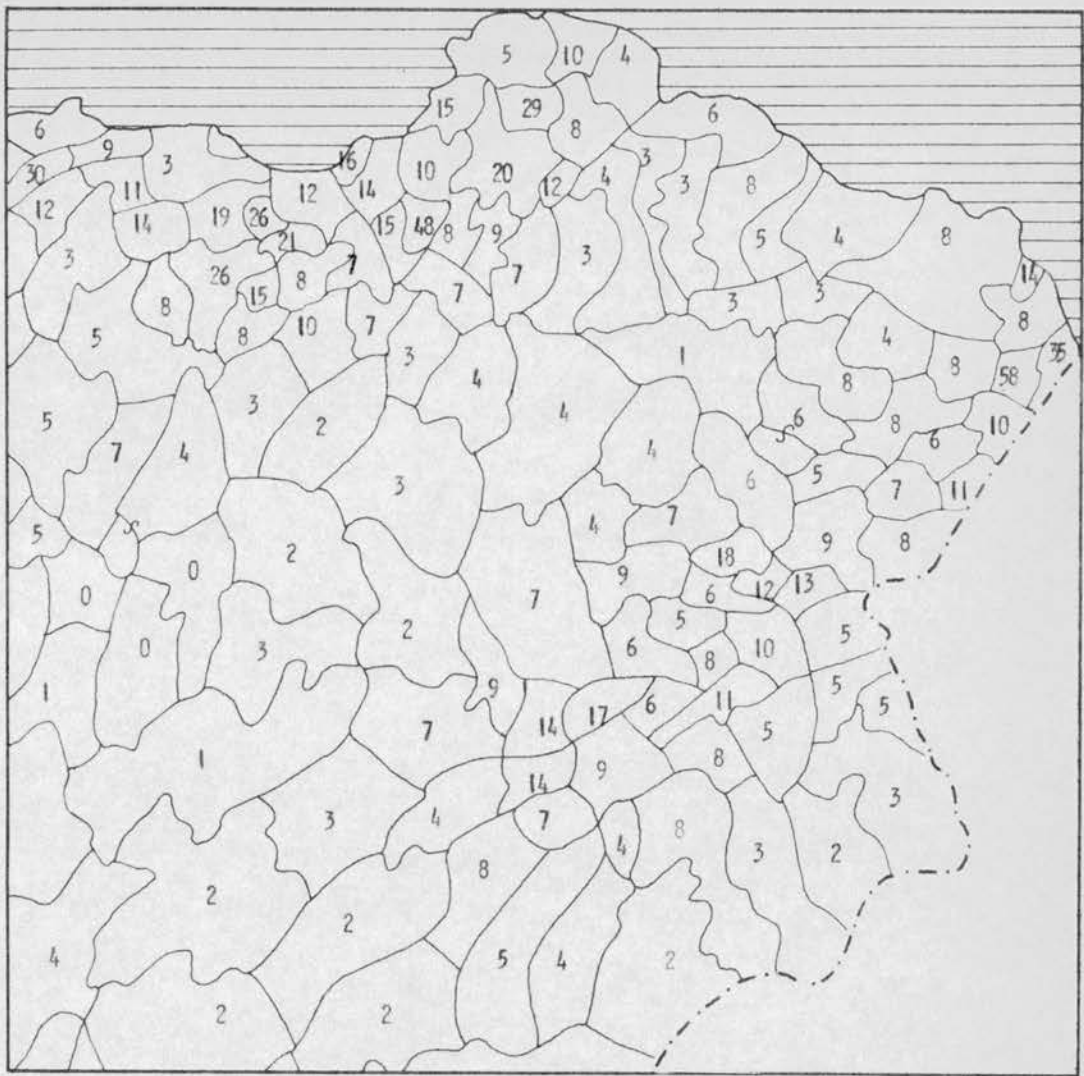


Figure 148

Vertical scale- 1mm. : 2 holdings

Number of holdings reported per unit area
in 1966



1 unit = 5 mm² or 14.7 sq.Kms

(1:625000)

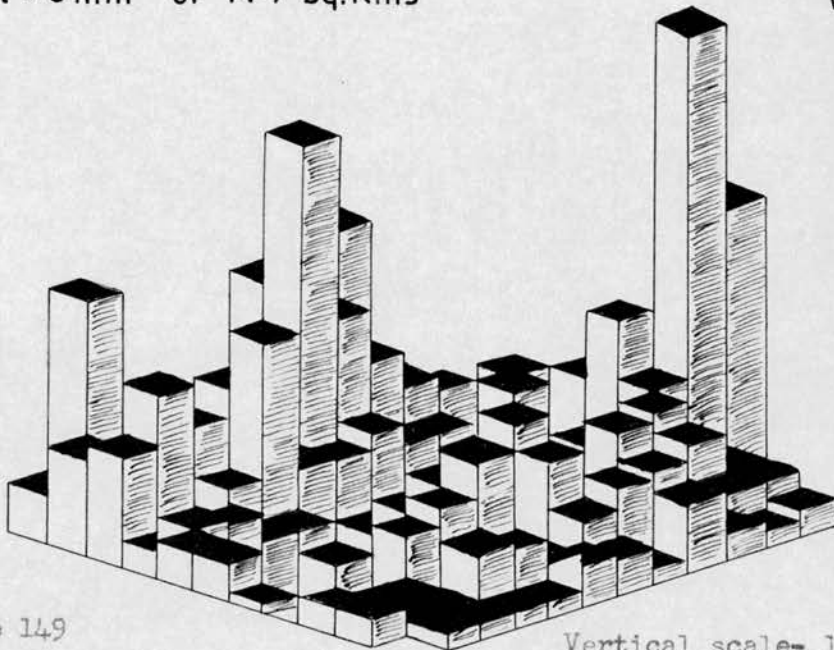


Figure 149

Vertical scale- 1mm : 1 holding

Number of holdings per unit area in 1966

of the cropping patterns eliminating alternatives besides grain, since mechanized harvesting equipment is rarely of the multi-purpose type.

Varying Ability to Produce Grain over Scotland

"Cereal yields have increased by a third in the last 20 years, mainly through better varieties, the introduction of chemical control for pest, diseases and weeds and increased mechanization. The modern trend in crop production is towards more intensive systems. There has been a dramatic increase in cereal production in the past decade and there is now considerable acreage in continuous or semi-continuous systems."¹ While this situation has been developing, the publishing of estimated annual yields begun in 1884 was discontinued after 1965, precisely at a time when acreage outputs for individual grain crops were increasing most notably.

The yield estimates were averaged and published on a county basis although they were gathered from a variety of sites over each county. The averaging has led to the loss of valuable statistical detail which would have been useful if different estimates could have been applied to the hill parts of the divided counties from those used in the arable lowlands. An illustration of the differing abilities to produce grain is provided in the following typical yield estimates in hundredweights in the country around Haddington and Eyemouth.²

1. See page 29, Jones, W. E., Straight from the Scientist's Mouth, in a special section on The Corn Merchant, The Times, January 26, 1967. Mr Jones is chief advisor in the National Agricultural Advisory Service.

2. Buckpitt, Hughes and Wallace, on page 174, Ch. 7 op cit. p. 303.

| 1967 | Low Ground | Upland | Hill |
|--------------|------------|--------|------|
| Oats | 30 | 26 | 20 |
| Barley | 33 | 28 | |
| Winter Wheat | 35 | | |
| Spring Wheat | 30 | | |

In the farms of the Merse of Berwick typical average yields in recent years were placed at;
1960

| | | | |
|--------------|----|----|---------------------------------------|
| Oats | 30 | 23 | |
| Barley | 31 | 26 | |
| Winter Wheat | 28 | | |
| Spring Wheat | 25 | | hundredweights per acre. ¹ |

If a breakdown had been available on this basis of low ground, upland and hill, the output for the more arable lowland areas might have been shown as higher and the less arable upland parts as lower than they have been in the following representational material.

In addition to change in patterns due to research efforts, Scotland has a considerable variation in patterns latitudinally and locally. Many of these variations are susceptible to further research on the micro-scale and offer a vast field of interest to researchers in the future. The patterns are discussed and illustrated here on the macro-scale. Production number pattern maps by divided counties and counties, graphs by counties and regions, raised statistical surface maps by divided counties and bar graph maps are offered as illustration of the varying ability to produce grain in the country. In the first few years of the estimates a good deal of care was taken to experiment with the method until a suitable organization had been set up. The estimates for 1884 were for Scotland as a whole only. The county estimates were published from 1885.

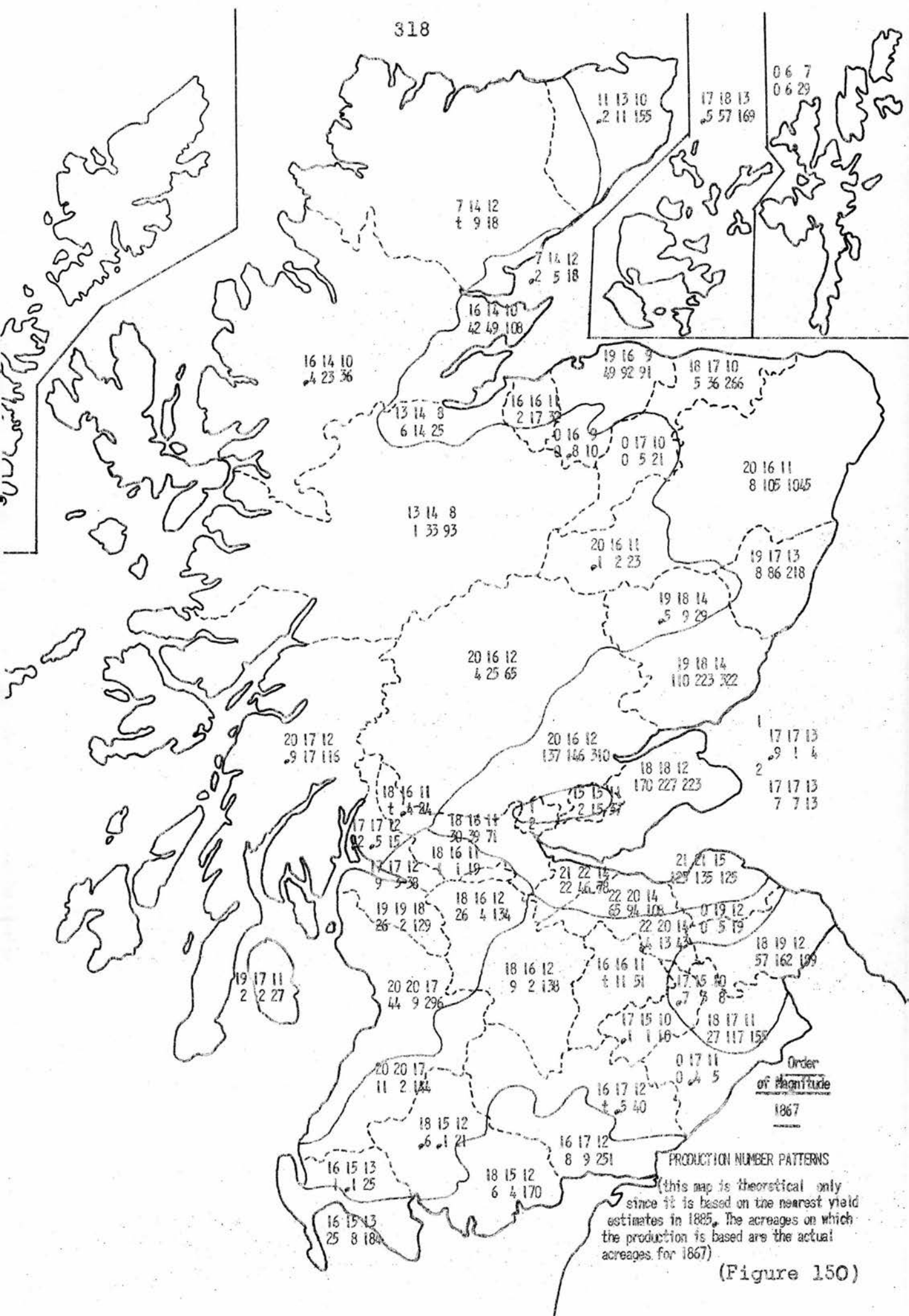
1. Buckpitt and Corner, p. 129 op cit. page 304.

Production Number Pattern Maps

A year by year picture over Scotland from 1885-1965 is presented in the production number pattern maps (Appendix E). In addition a theoretical 1867 production picture is shown for 1867 related to the first yield estimates given in 1885 on a county basis (Figure 150). It is assumed for the sake of illustration that yields in 1867 would be somewhat similar to those in 1885 and the result is to give an order of magnitude of production only. The first line of the pattern gives the estimated hundredweight yields per acre (the bushels per acre estimates were converted to hundredweights at the weights suggested) gathered by county experts from as many as 100 to 350 sources¹ in the county, and averaged for the whole county annually. The county estimates were given in bushels per acre from 1885 until after the Corn Production Act 1917 when both bushels and hundredweights were offered and later confined to the hundredweight estimates. Where bushels were given, the average weights for the different grains were suggested by years, the change to the weight estimates made this unnecessary.

After the initial experimental period of estimates, the 1889 yield estimates for wheat per acre varied from a low of 14.6 on a very few acres in Caithness to 26.8 in Renfrew; barley per acre varied from 12.3 bushels in Shetland to 22.9 in Renfrew on a few acres or 21.3 in the larger production area represented by Midlothian; and oats per acre

1. See page 205 (page numbers entered in ink to link several government command papers together) Agricultural Produce Statistics, Great Britain, 1884-85, Volume LXXXIV, National Library (Edinburgh) Scotland



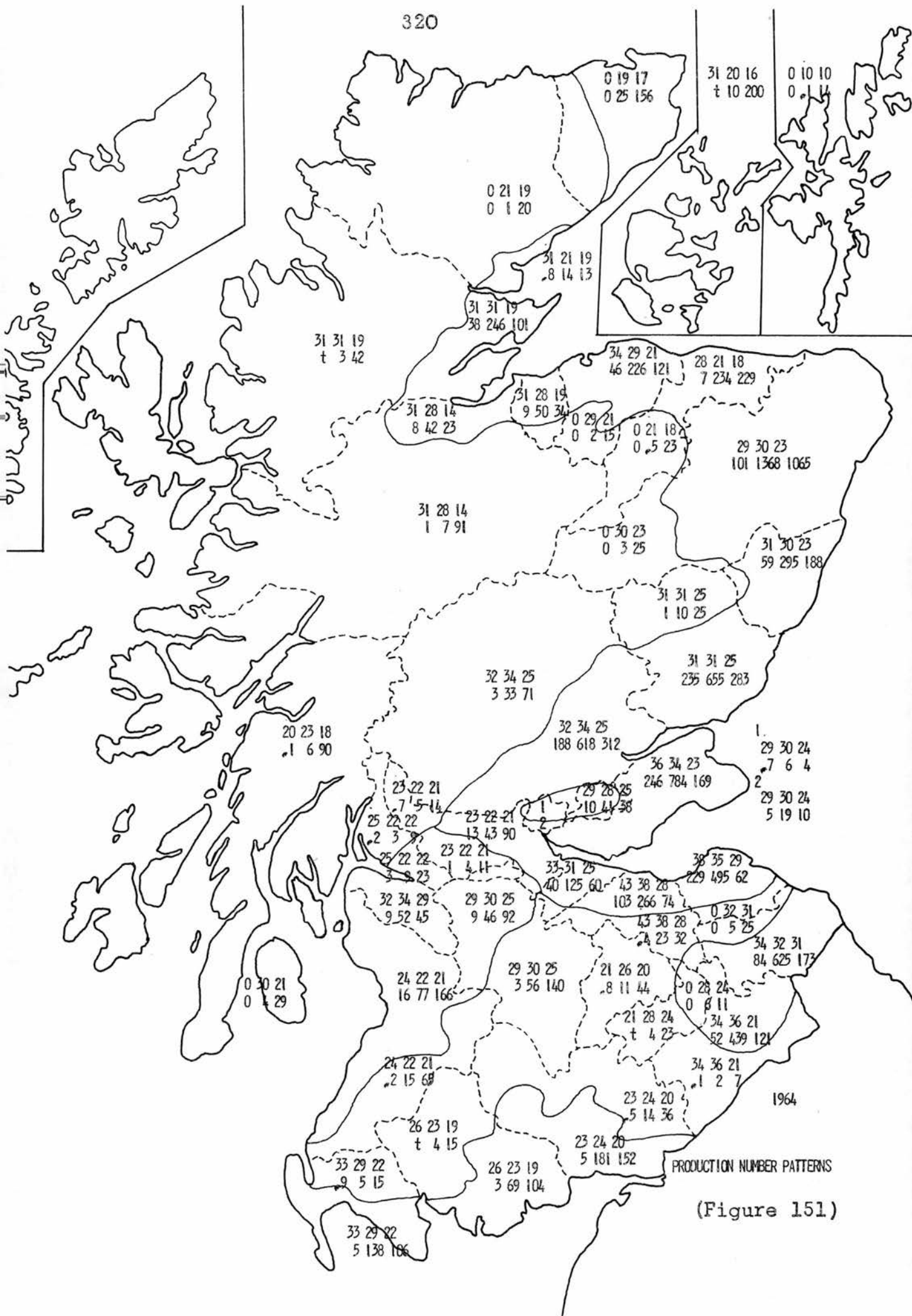
(Figure 150)

varied from 6 bushels in Shetland to 11.5 in Argyll and 17.1 in Angus. In 1964 (Figure 151) yields of wheat up to 43 cwt per acre, barley 38 cwt and oats 31 cwt, were estimated with variations regionally to much lower yields. It is not sufficient to compare just two years but the year by year situation may be examined by consulting the full sequence of production number pattern maps in Appendix E. The 1867 and 1964 graphs are samples only.

The second line of the production number patterns makes use of the estimated yields and the actual acreages of wheat, barley and oats reported by parishes and grouped into upland and lowland parts of counties and counties making 54 units. The output is expressed in hundreds of tons. The key production areas are quickly located and different groupings of the divided counties may be made to suit the crop at hand. For example, the Forth Regional output may be obtained for comparison with that of lowland Aberdeen or with lowland Perth, Angus and Kincardine and so on.

Line Graphs

Using the estimated hundredweight yields per acre, two sets of three graphs have been drawn using first the county then the region as the base unit of reference. In the separate graphs for wheat, barley and oats in the counties of Shetland, Aberdeen and East Lothian (Figure 152) there is a consistent decrease in estimated yields from south to north. This situation was expected at the outset but its remarkable consistent relationship throughout the period could only be presumed until the estimates



PRODUCTION NUMBER PATTERNS

(Figure 151)

Estimated yield per acre, 1899–1964, by counties

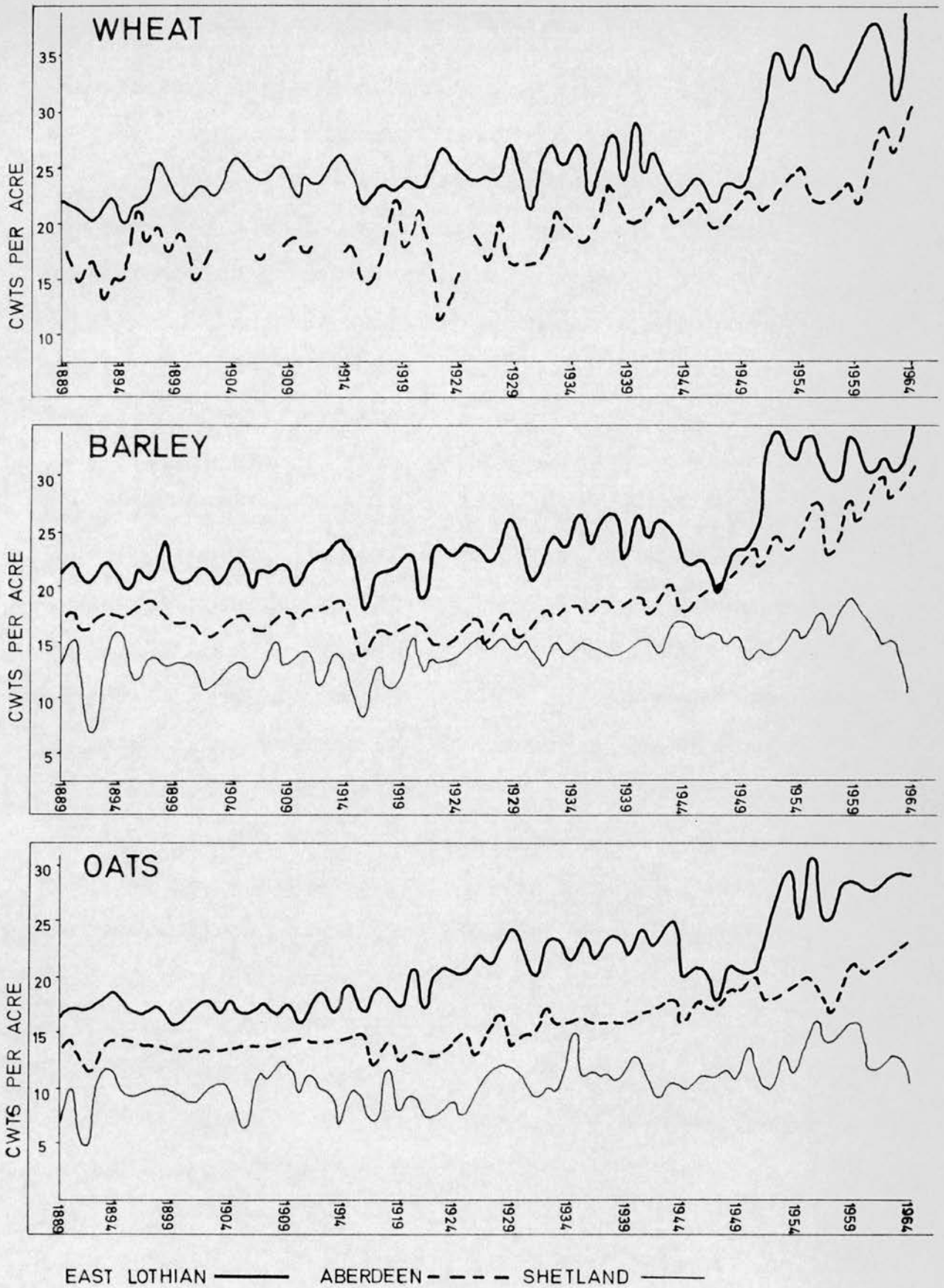


Figure 152

were plotted on the graphs. When grain regions were used the counties of Ayr, Wigtown, Kirkcudbright and Dumfries were used to represent the Southwest, the counties of Midlothian, West Lothian, Stirling, and Clackmannan to represent the Forth region and the counties of Ross and Cromarty, Inverness, Nairn, and Moray to represent the Moray Firth region (Figure 153). Again the results are consistent although revealing more interchangeable pattern than the county-based lines from the three widely separated counties. The Forth region reports the highest yields of wheat, barley and oats generally. There is a strong tendency for the Moray region to have similar patterns or to interchange estimated yields with the Southwest region. A good many of these year to year patterns are explainable by the annual vagaries of the weather and the increases in yields after 1955 with the help of newer seed varieties. However, the spaced aspect between the estimates by counties or grouped in regions has to do with differing regional conditions for grain production. These conditions prevailed consistently throughout the period shown 1889-1964 and reflect the quality of the estimates which were made by a large number of estimators in the field with the help of reports from hundreds of farms, and were later averaged on the county basis.

Raised Statistical Surface Maps

Four maps for the years 1889, 1918, 1939 and 1964 give a cross-section of the situation over the greater part of the 1866-1966 century and reflect the changing conditions described and represented in other ways but

Estimated yield per acre, 1899–1964, by regions

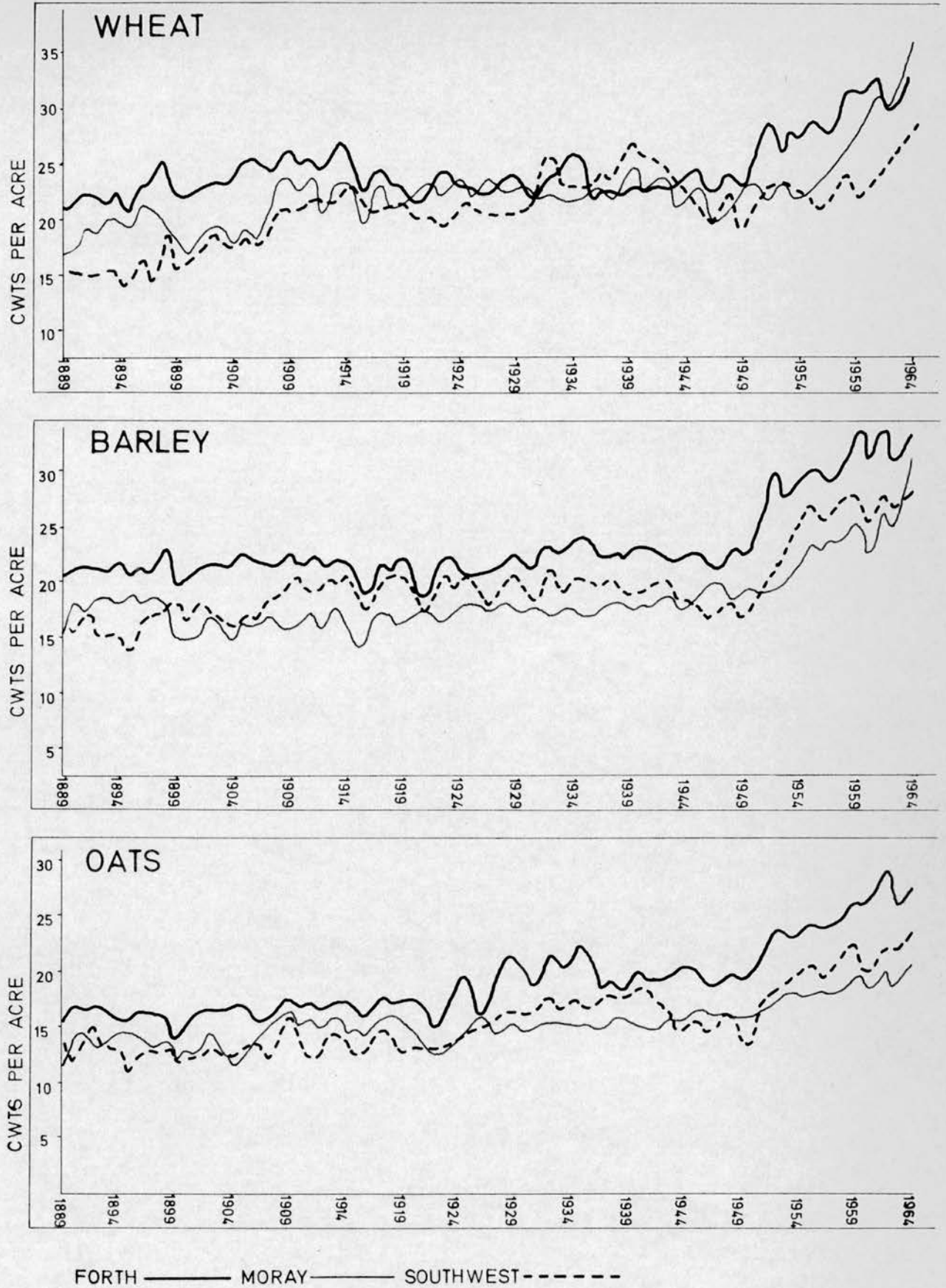
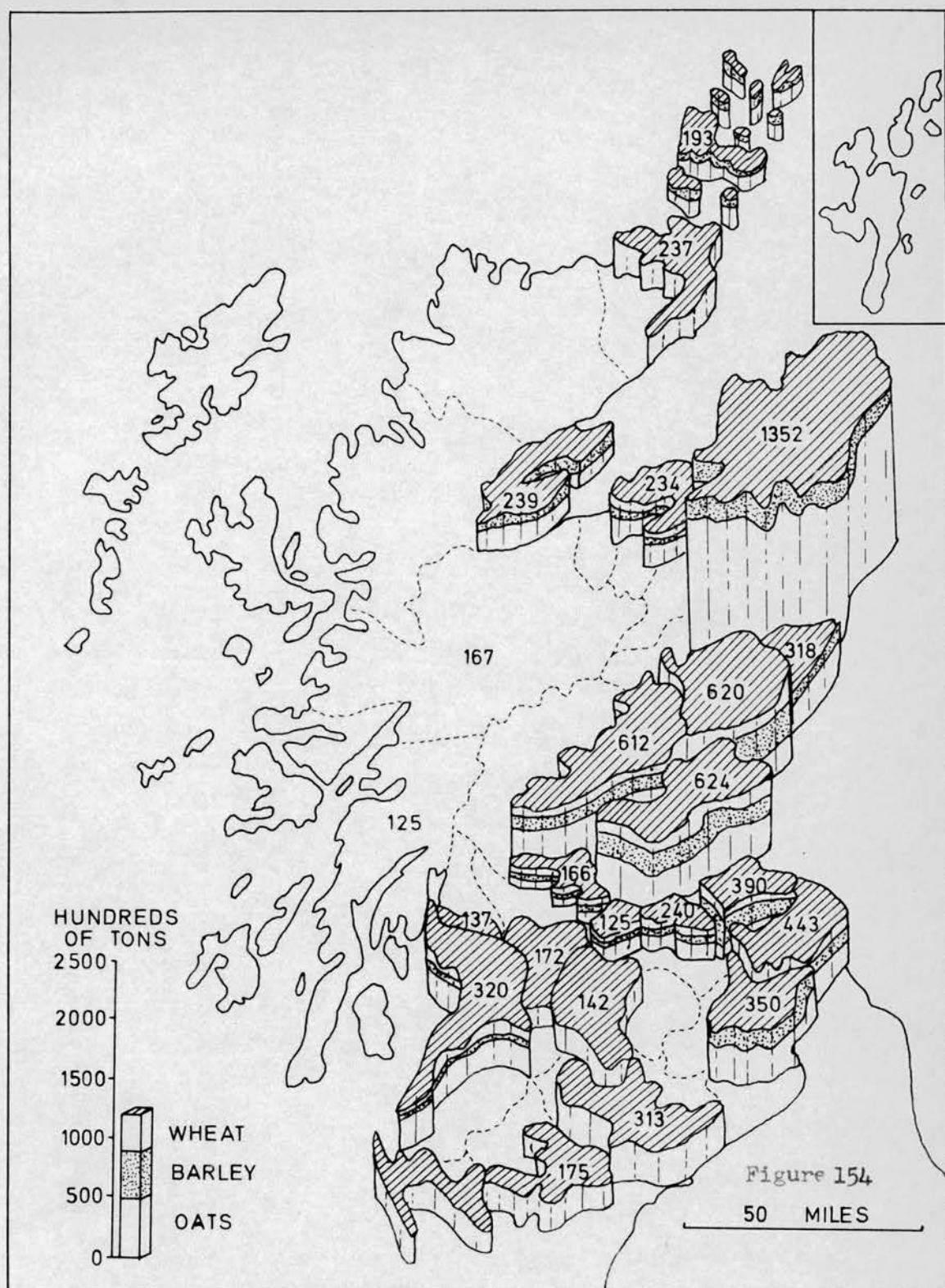


Figure 153

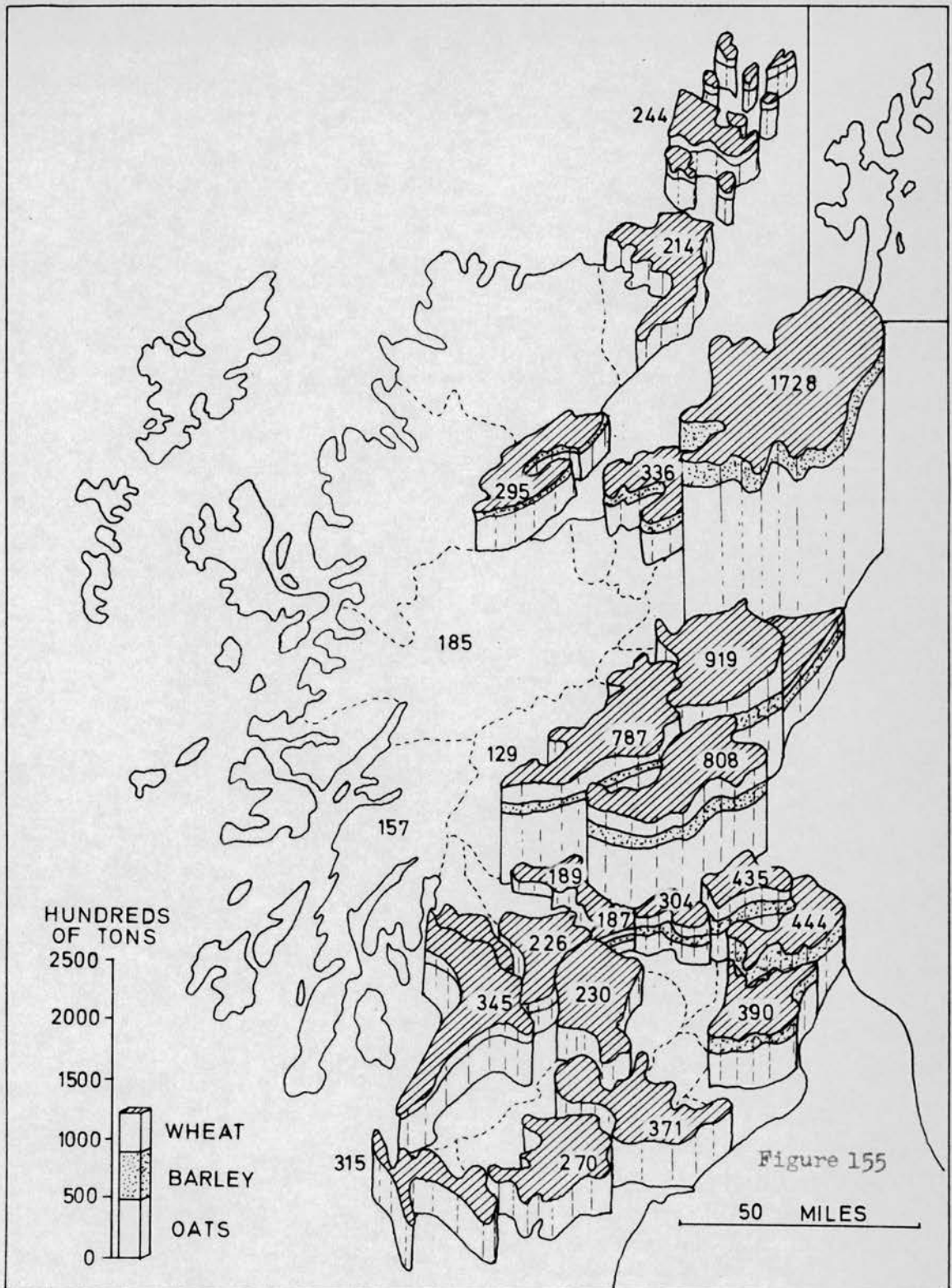
with a striking difference (Figures 154, 155, 156 and 157). The maps deal with total grain output in hundreds of tons. The more arable parts of the divided counties are raised to a vertical scale of 500 tons per centimetre and the total raised block subdivided into the three main grains. Tonnages exceeding 10,000 tons are shown although those representing the large highland-upland areas are not raised. To do so would be to attribute production over a wide area when it should be shown on a different scale of maps by certain parishes only. When completed the maps were reduced slightly, so that vertical measurement now reveals that 9.5 millimetres stands for 500 tons rather than 1 centimetre.

The maps are very effective in showing examples of the increasing specialization in grain in certain counties such as in lowland Aberdeen, Angus and Perth, around the Firth of Forth and in Berwick and Roxburgh. The increasing importance of barley is also dramatically shown. Since the total tonnages are given on the raised surfaces, the areal comparability of the maps is improved and they can be compared with the two raised acreage maps in the same series (Figures 86 and 87 on pages 203 and 204).

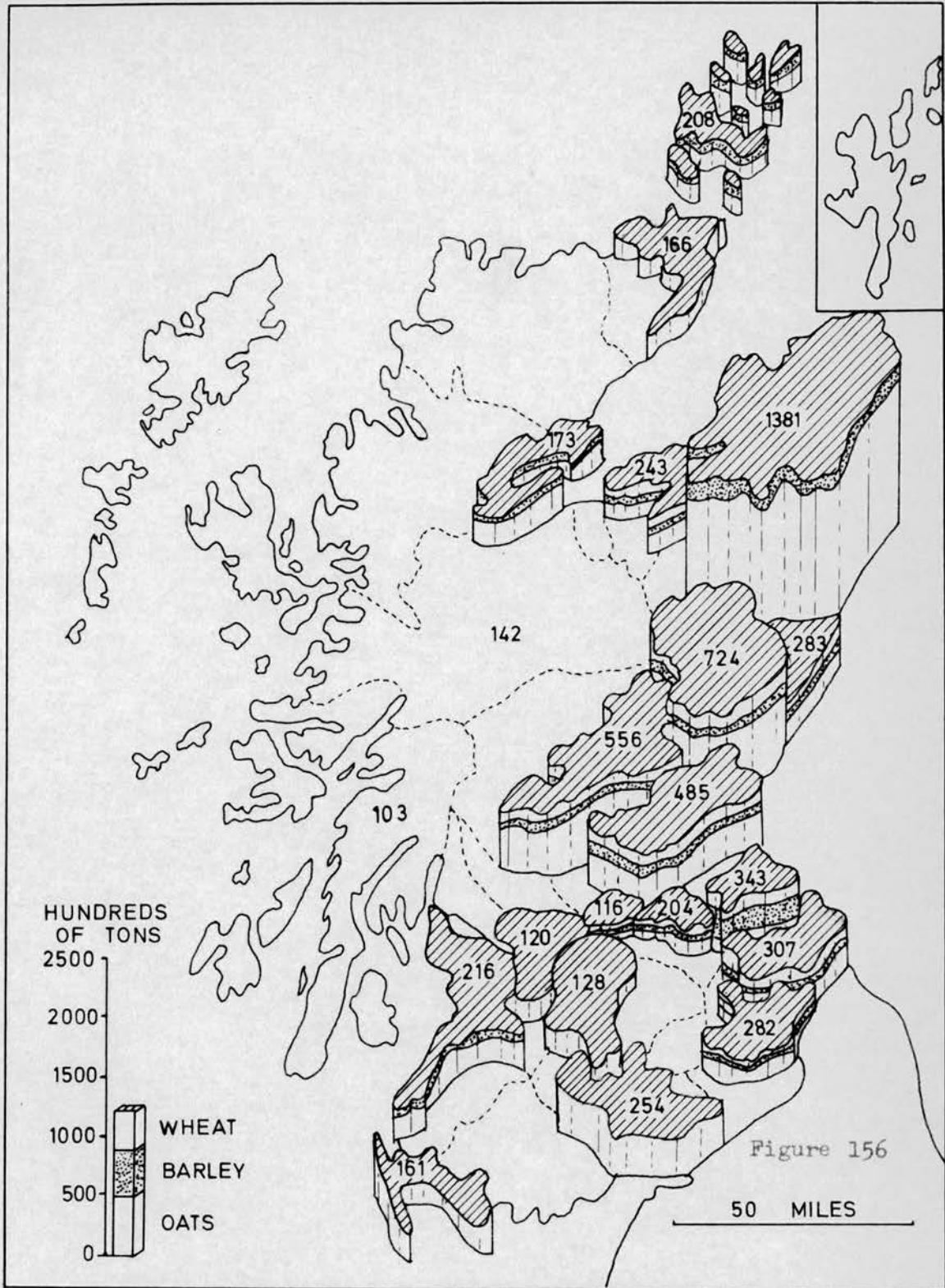
Banff is entirely hidden by the raised surface of arable Aberdeen. In the four sample years the lowland part of Banff produced 394, 459, 341 and 470 hundreds of tons of grain. The details for all 54 unit divided counties and counties may be found for the full sequence of years in the production number pattern maps.



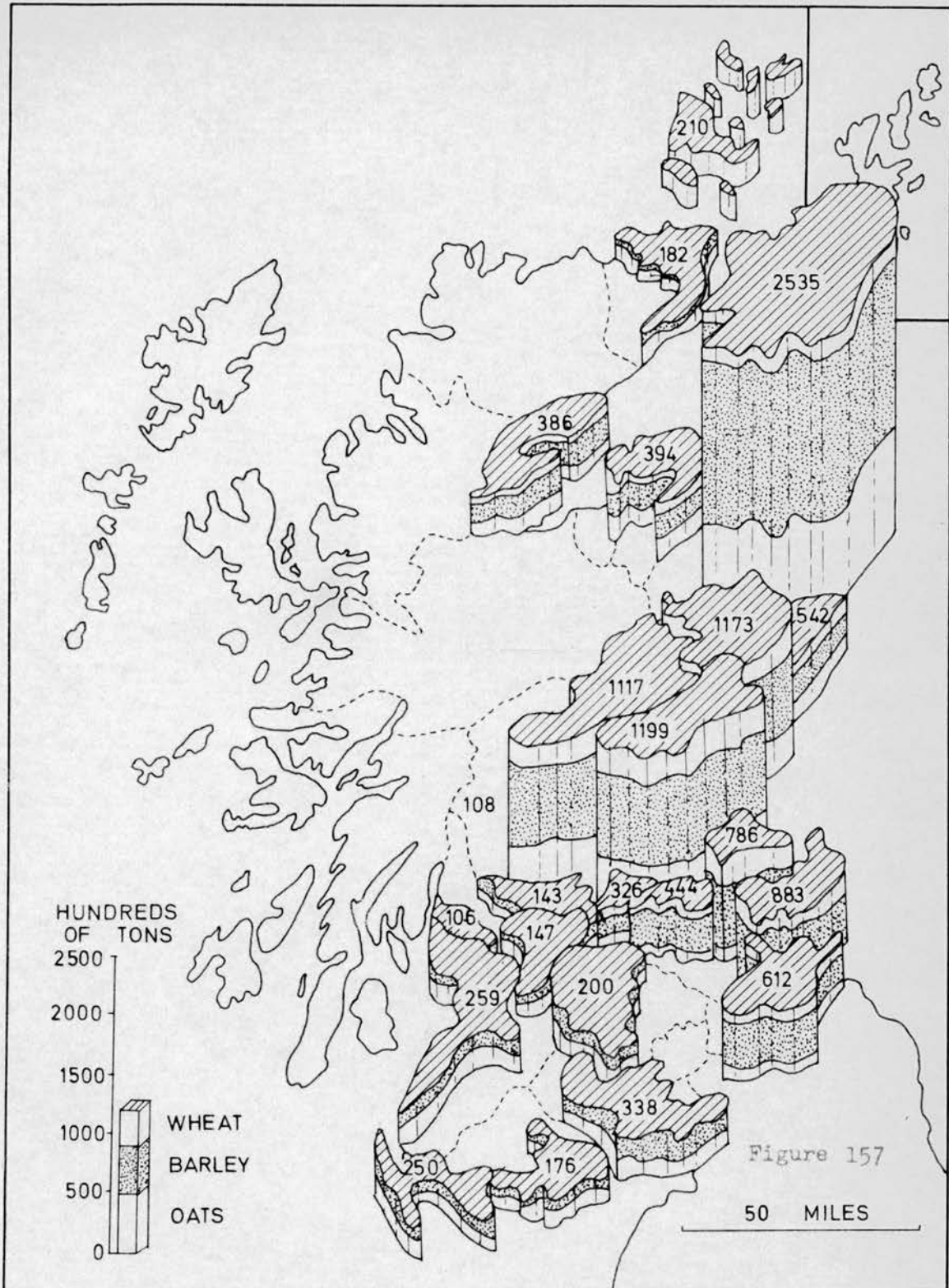
Estimated total grain output, by divided counties,
in 1889



Estimated total grain output, by divided counties,
in 1918



Estimated total grain output, by divided counties,
in 1939



Estimated total grain output, by divided counties,
in 1964

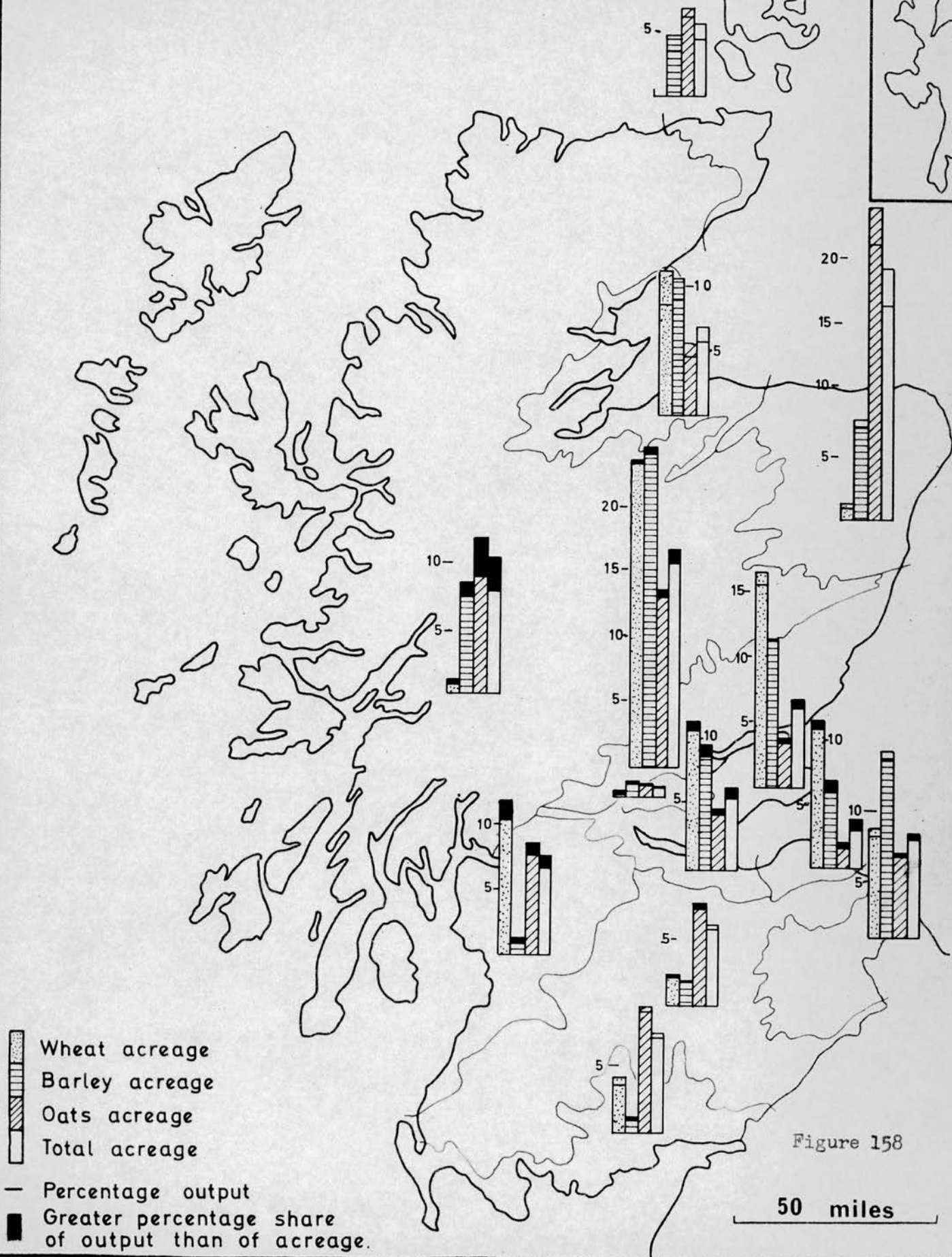
Bar Graph Maps

The regional percentage share of acreage and output over Scotland is clearly shown in 8 maps giving the wheat, barley, oats and total grain patterns by bar graphs by grain regions in selected peak, trough and more average years 1867-1966 (Figures 158-165). Another 5 additional maps comparing wheat production in the 8 sample years on one map, and then repeating the process for barley, oats, total grain and crops and grass, are repeated here though some of them were used previously as examples under the individual crop headings (Figures 166-170). They are a set and should be seen together at one time.

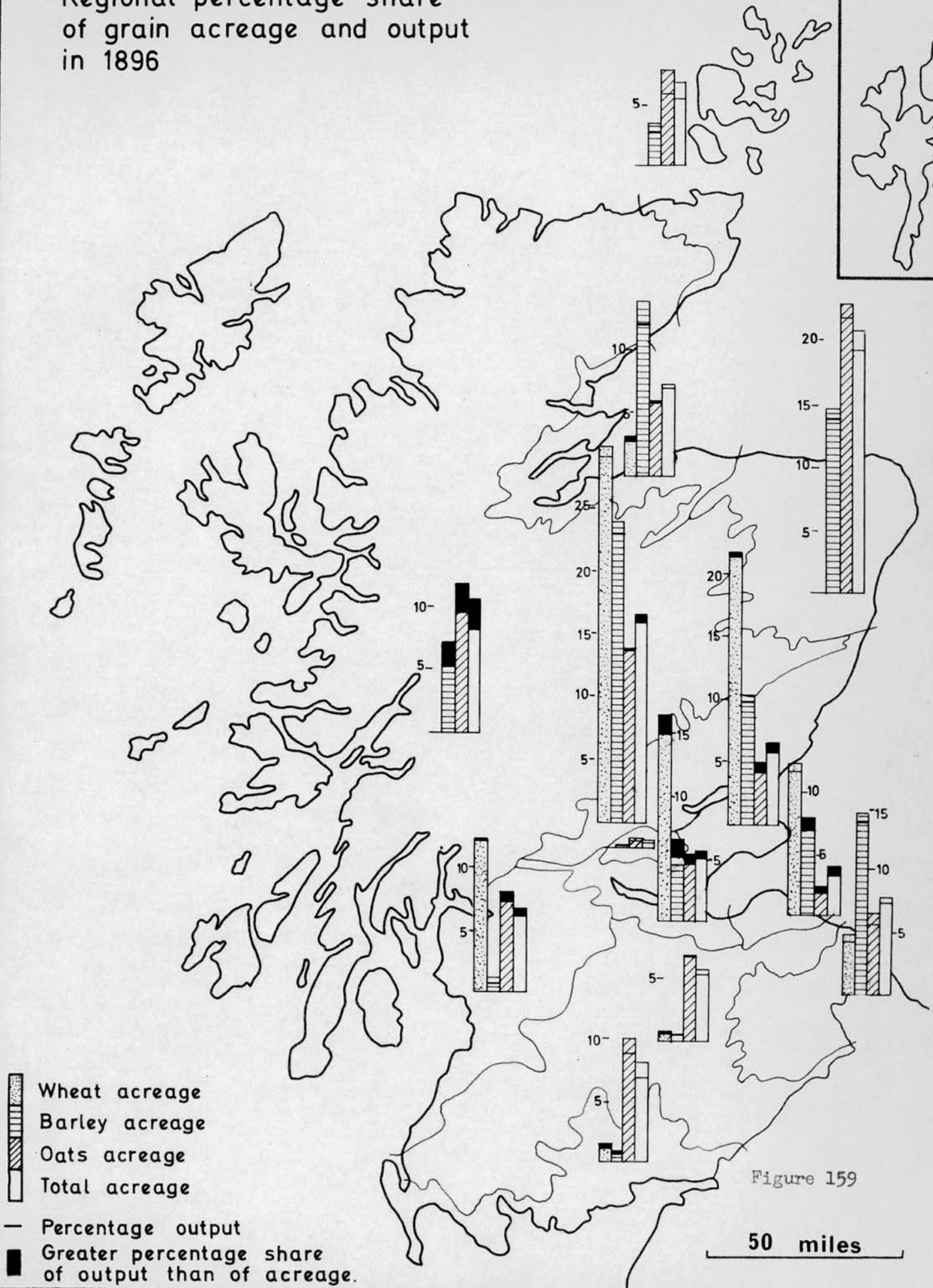
These bar graph maps show by means of heavy lines or shaded blocks at the top of the bars that total yields are higher in some places than in others. In Aberdeen there are always large acreages devoted to grain but the output is less than the national average per acre, whereas in Perth, Angus and Kincardine it is usually higher than the national average. The Forth counties generally show a pattern of higher output as well and on smaller acreage equivalents than Aberdeen or Perth etc.

In 1867 there was much more wheat and barley in the highland-uplands when small crofts were still numerous. The 1867 map is highly theoretical since the nearest estimated yields per acre by counties were those given in 1885. These were used to give a measure of the size of possible output only. The appearance of highland-upland production as greater than the national average in 1867 and 1896 is likely due to

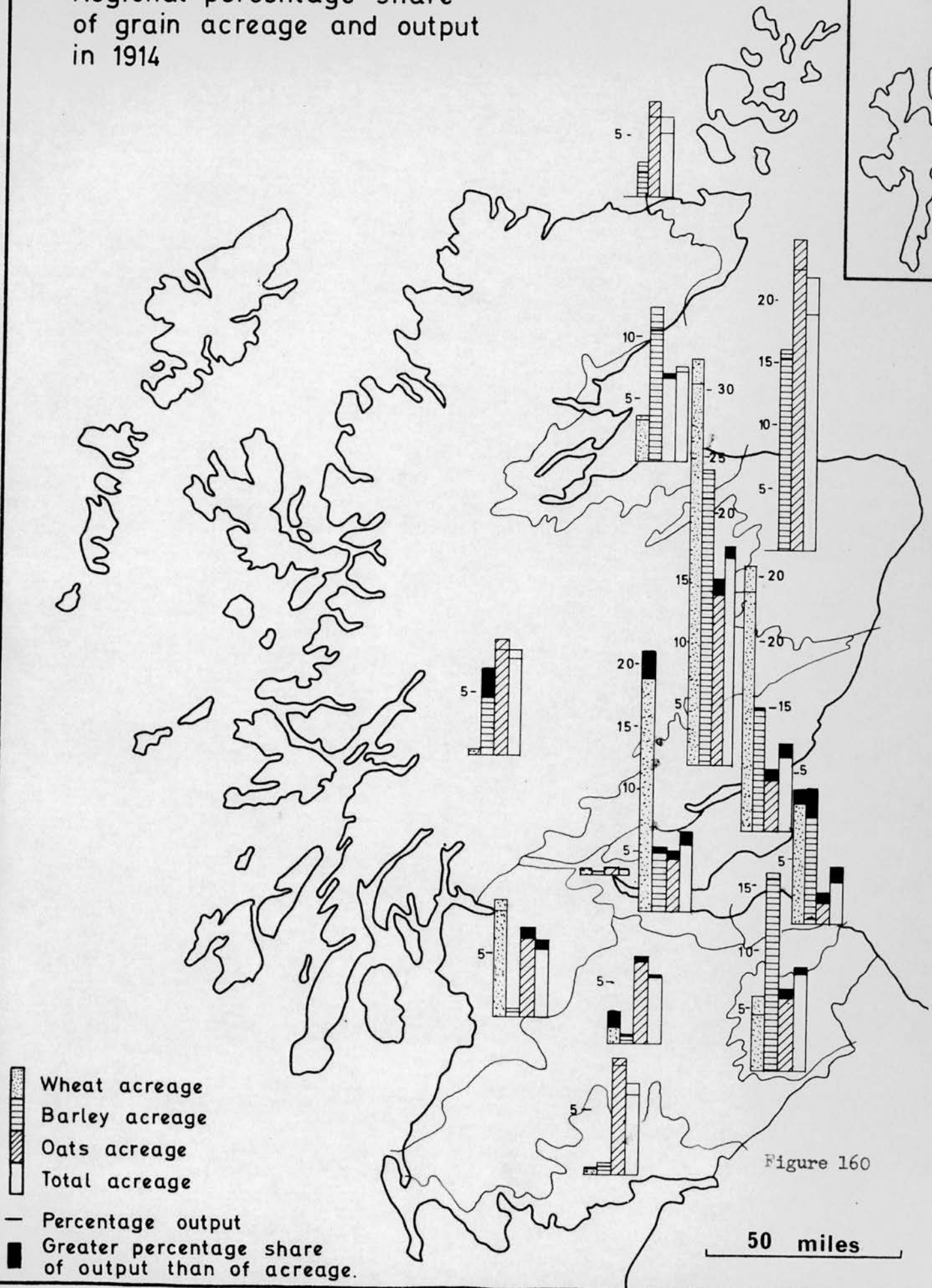
Regional percentage share of grain acreage and output in 1867



Regional percentage share of grain acreage and output in 1896



Regional percentage share of grain acreage and output in 1914



Regional percentage share of grain acreage and output in 1918

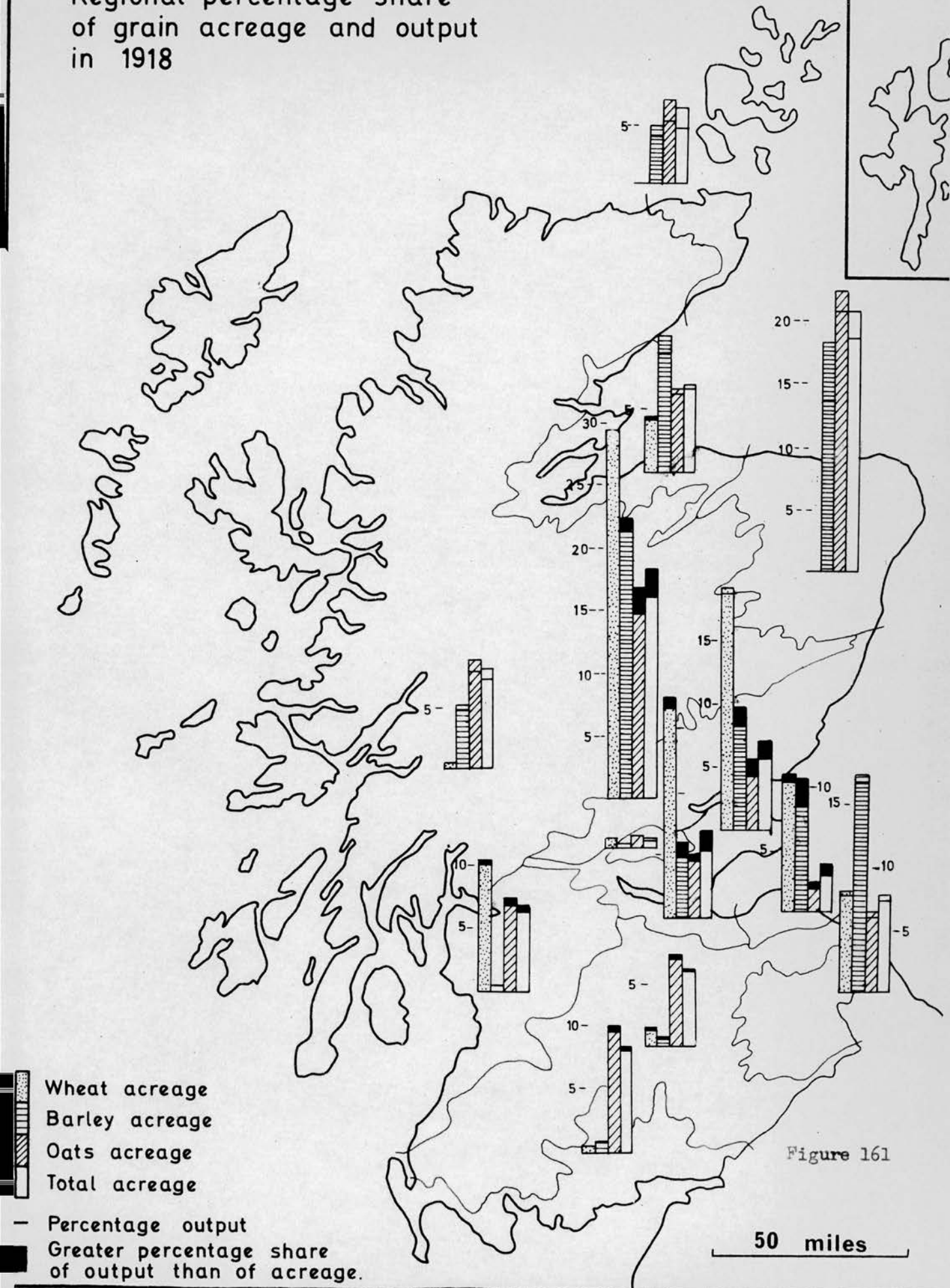


Figure 161

50 miles

Regional percentage share of grain acreage and output in 1939

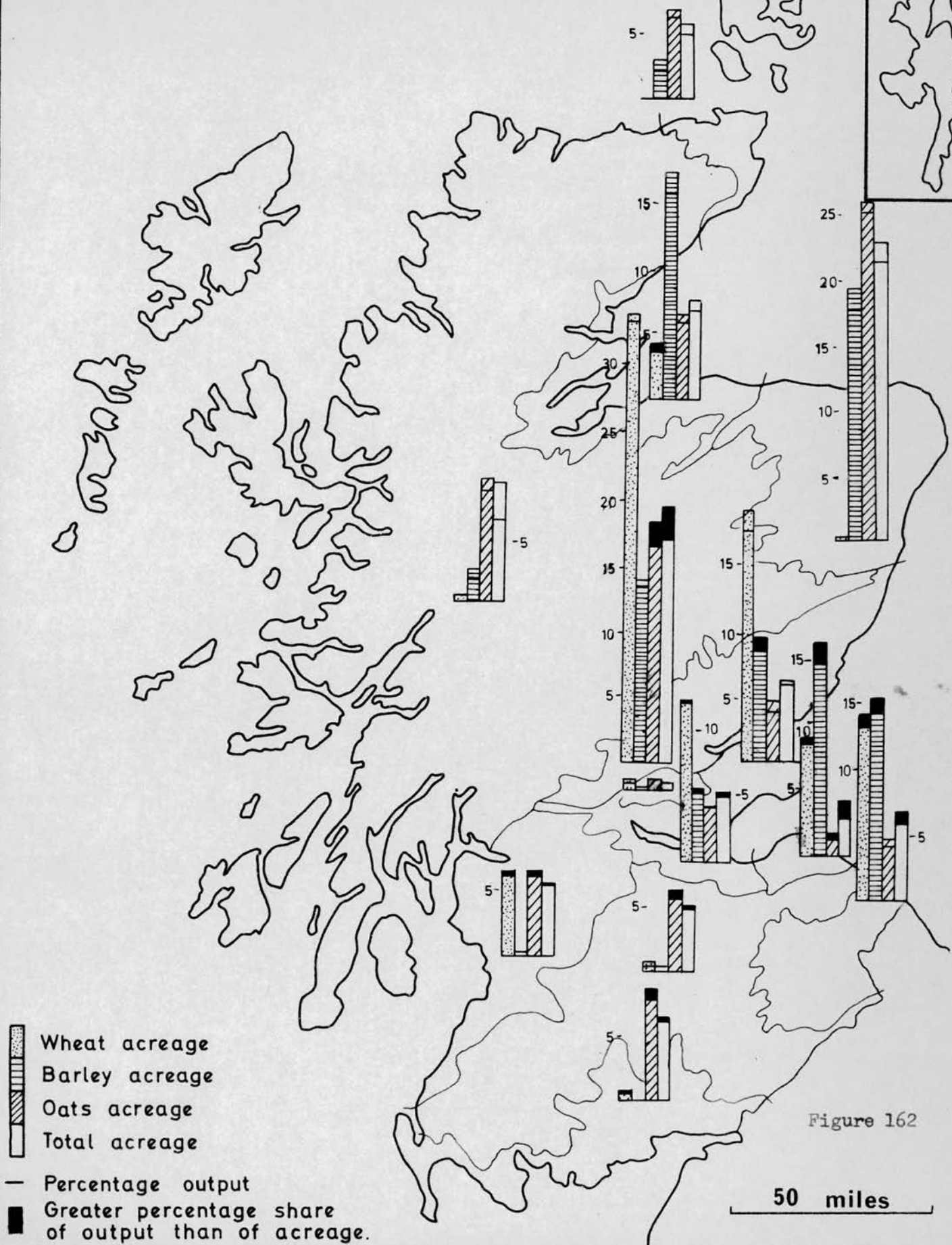
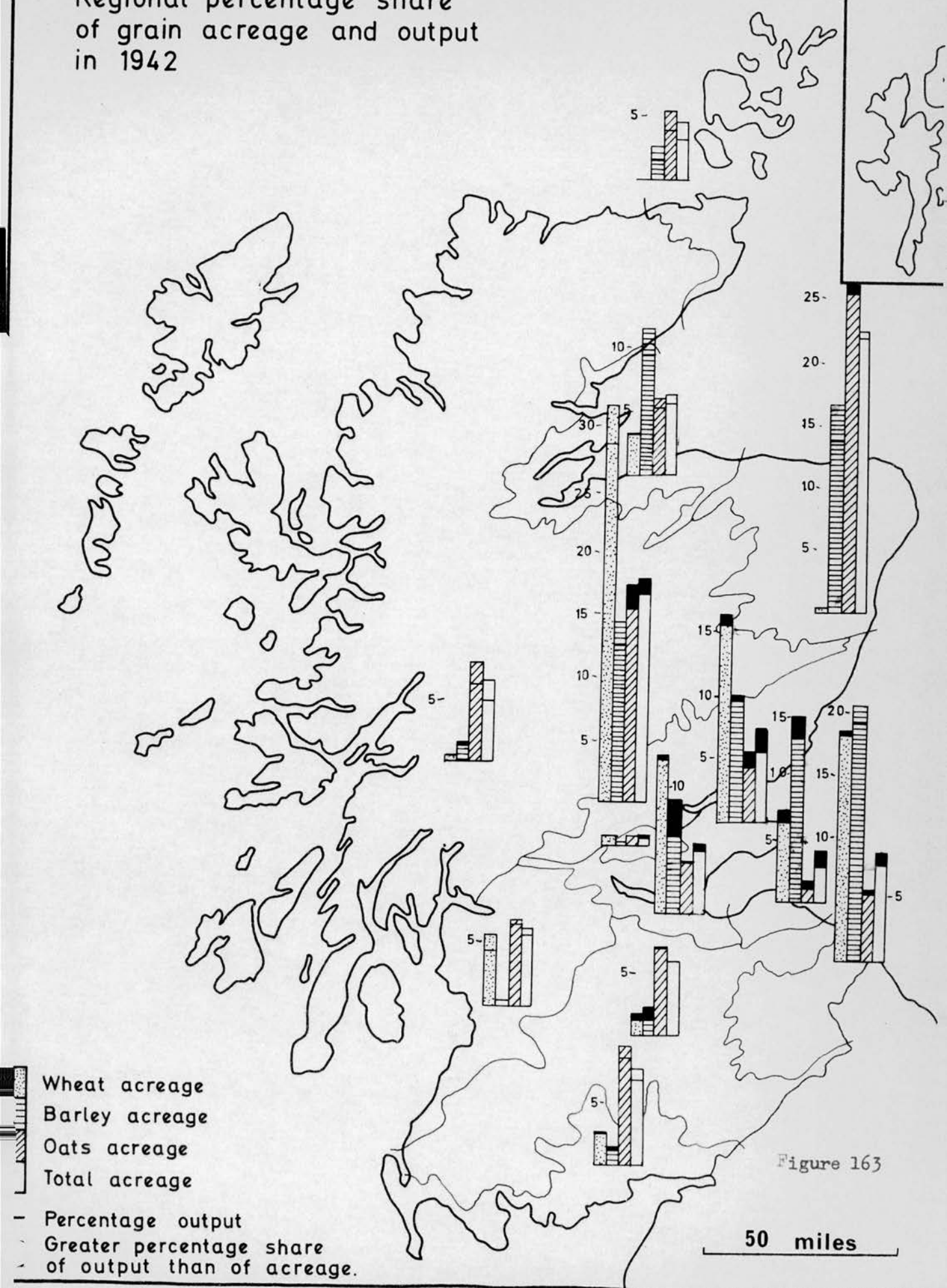


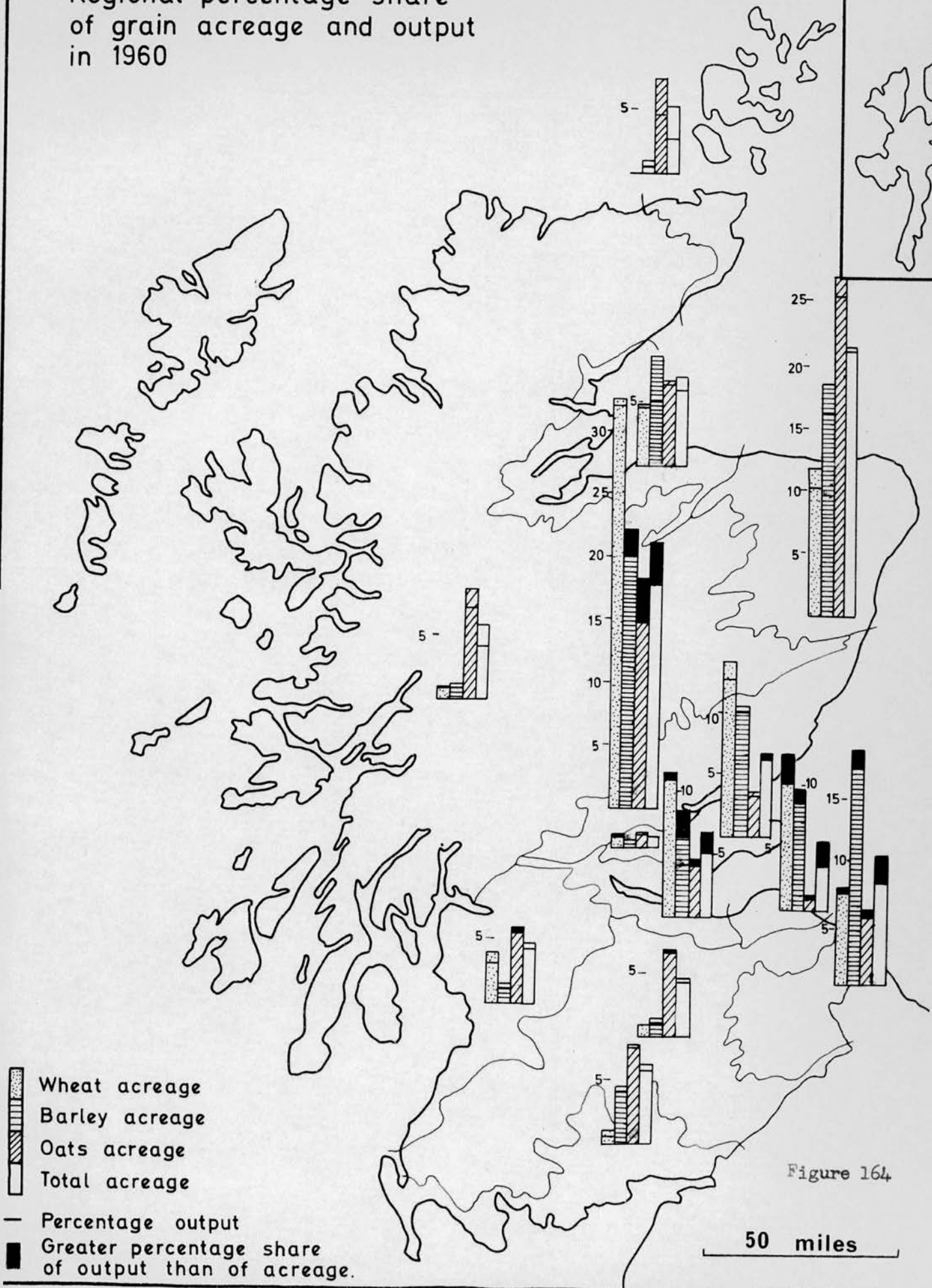
Figure 162

50 miles

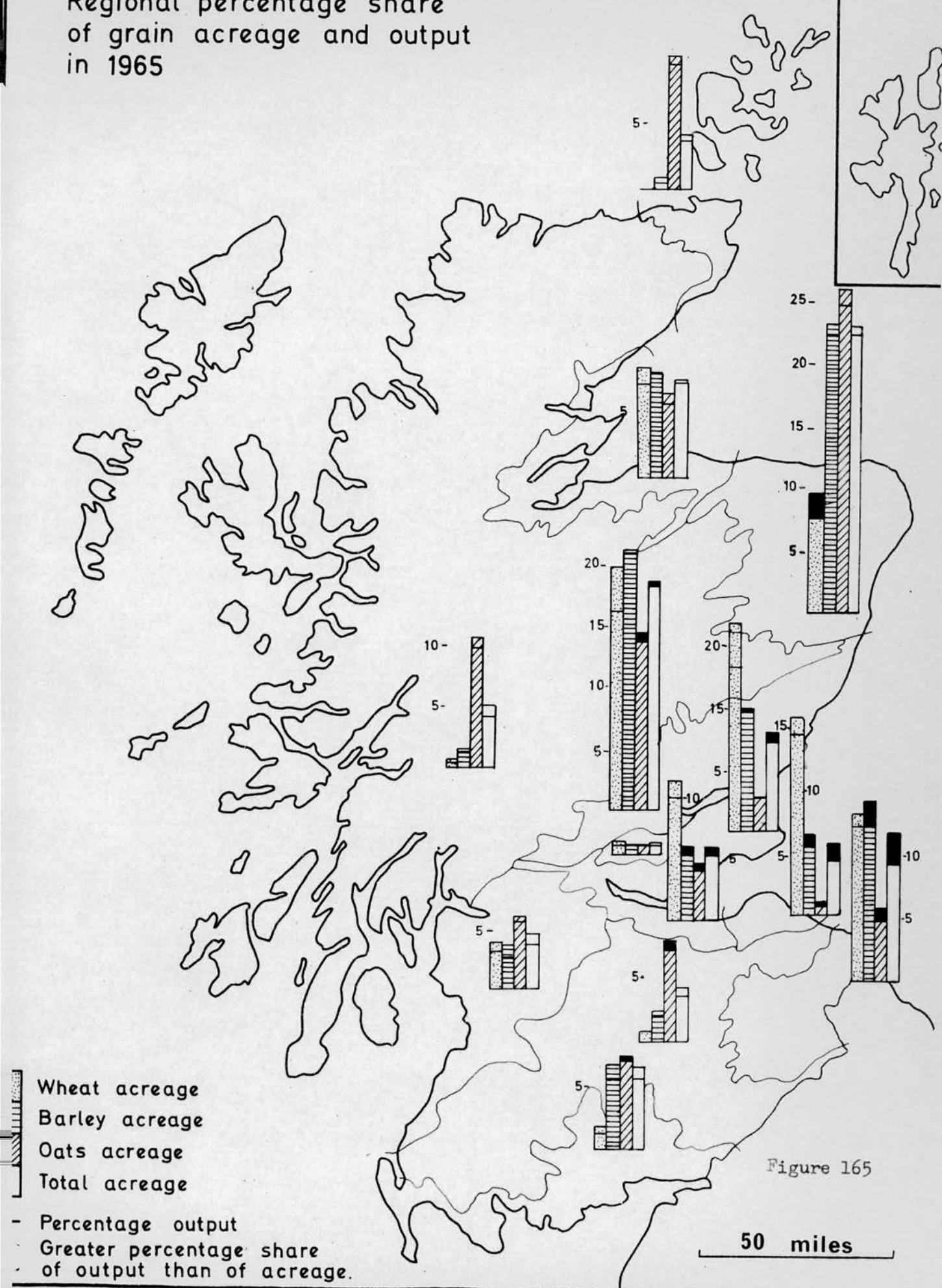
Regional percentage share of grain acreage and output in 1942



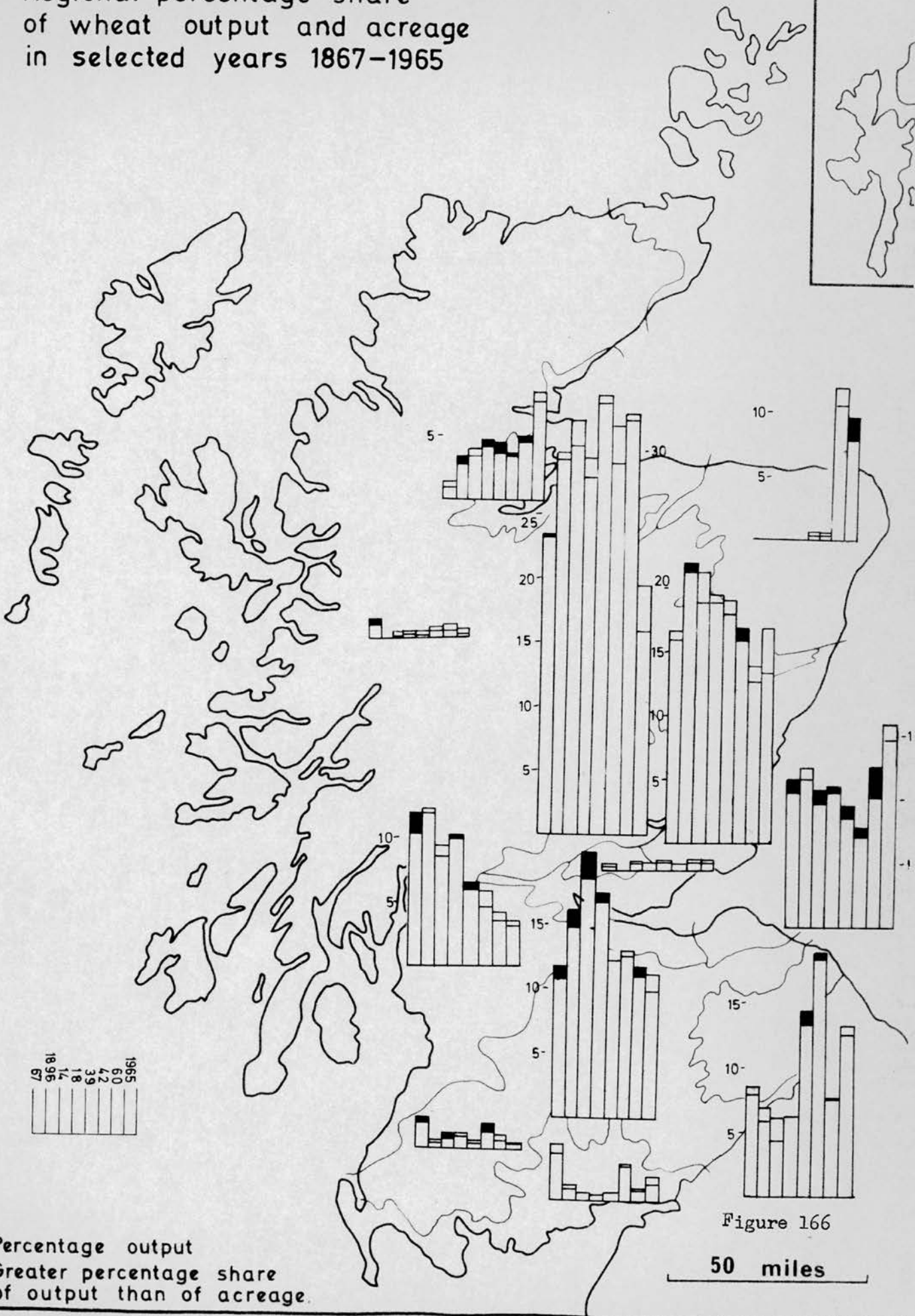
Regional percentage share of grain acreage and output in 1960



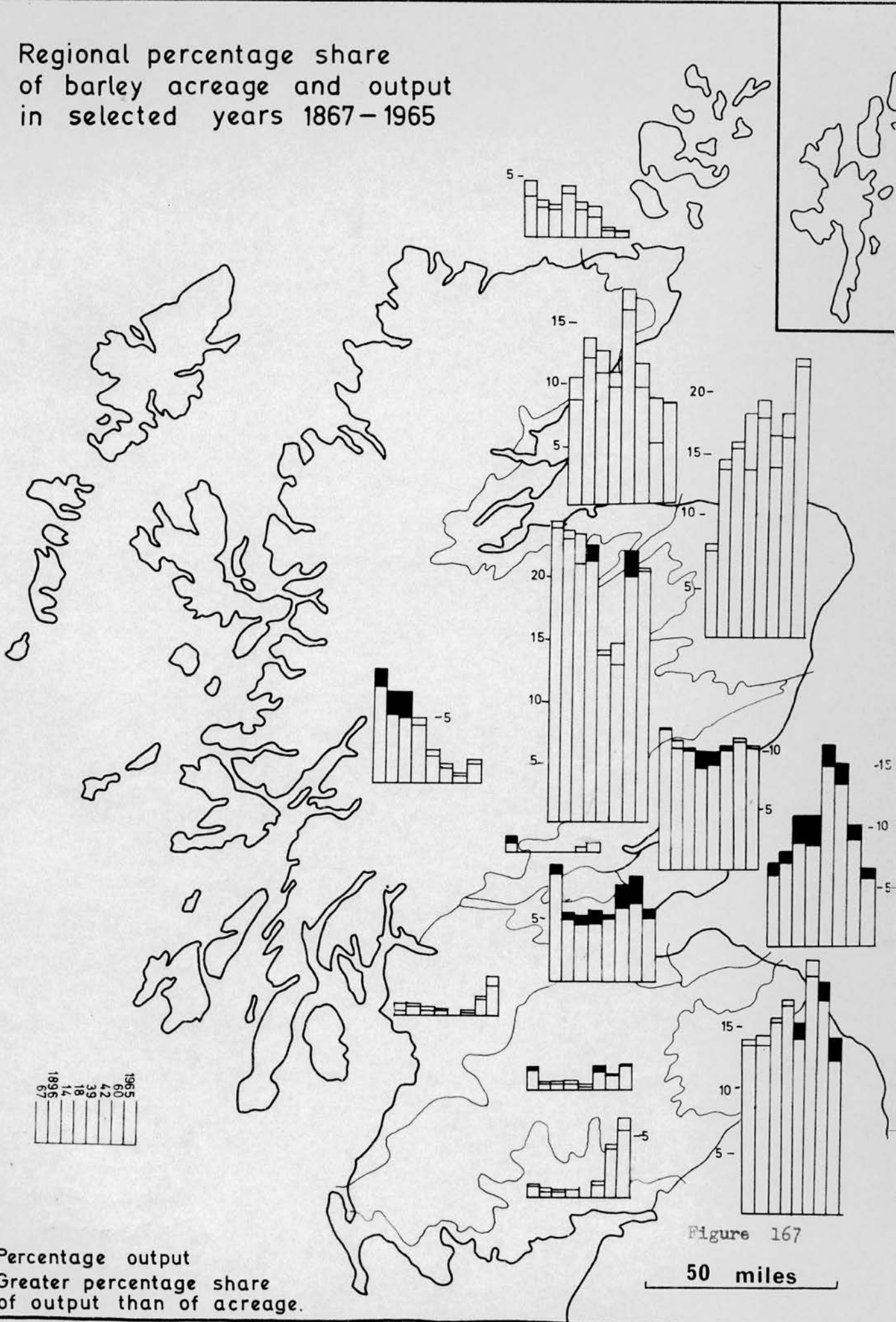
Regional percentage share of grain acreage and output in 1965



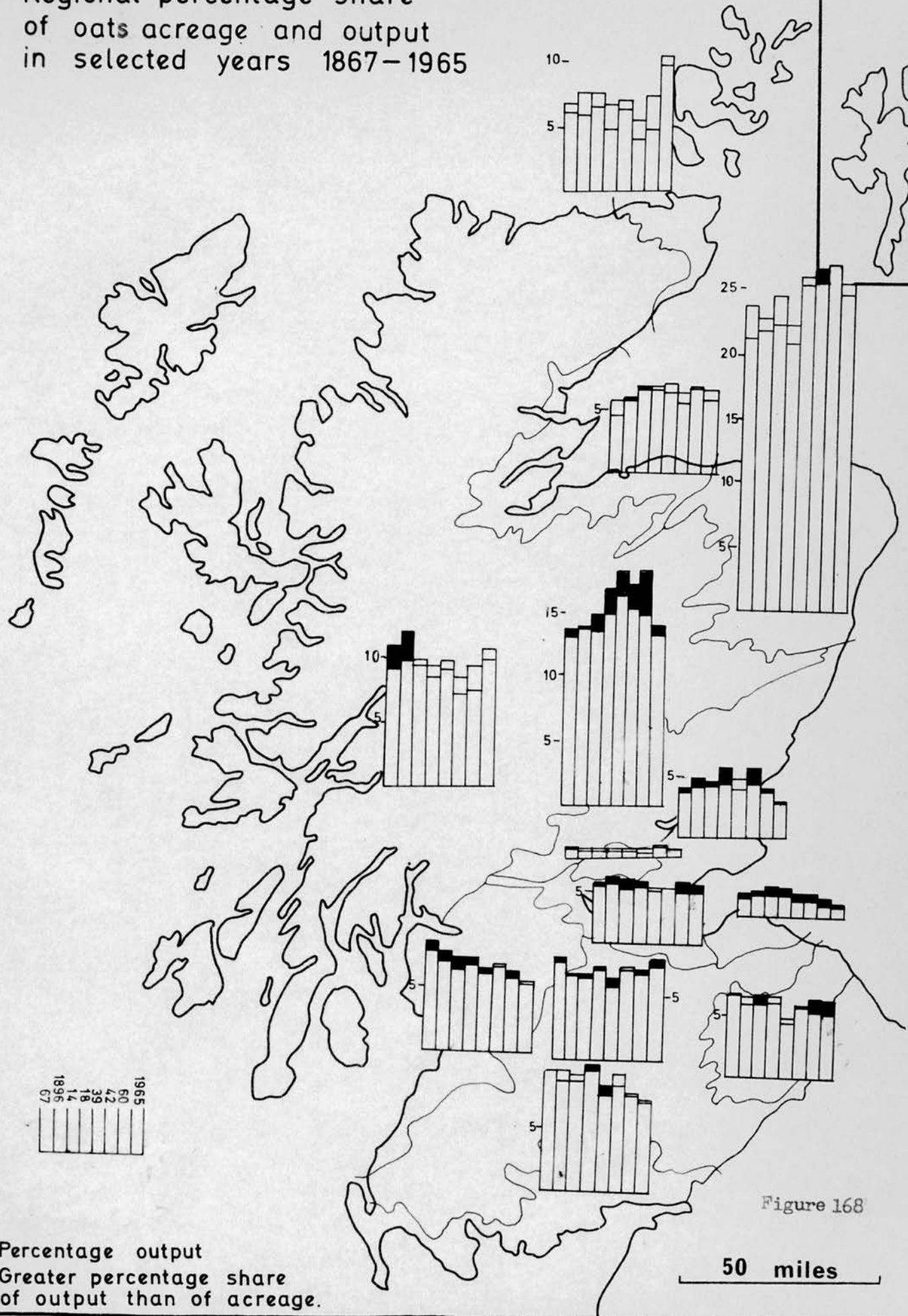
Regional percentage share
of wheat output and acreage
in selected years 1867-1965



Regional percentage share of barley acreage and output in selected years 1867-1965



Regional percentage share
of oats acreage and output
in selected years 1867-1965



Regional percentage share
of grain acreage and output
in selected years 1867-1965

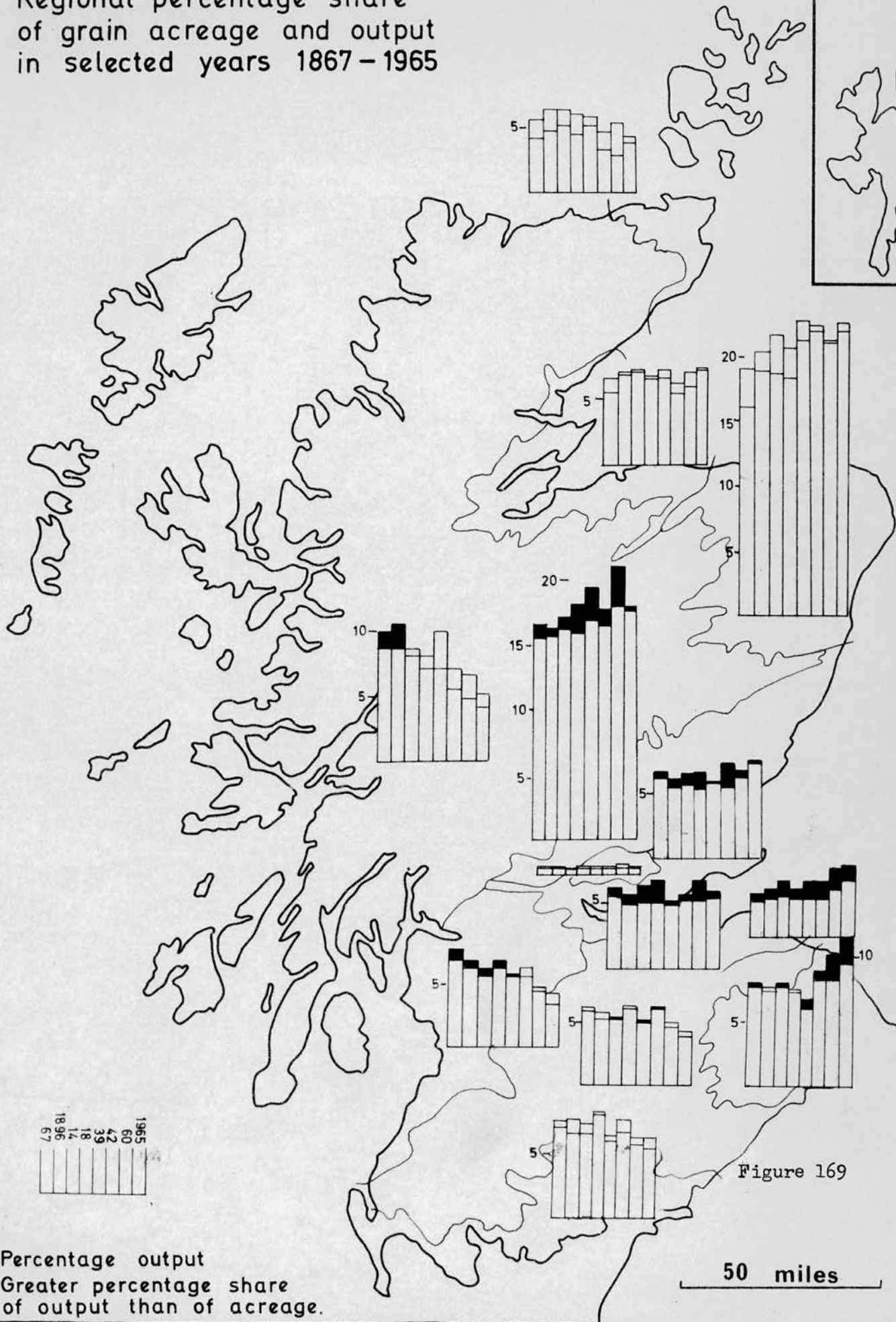
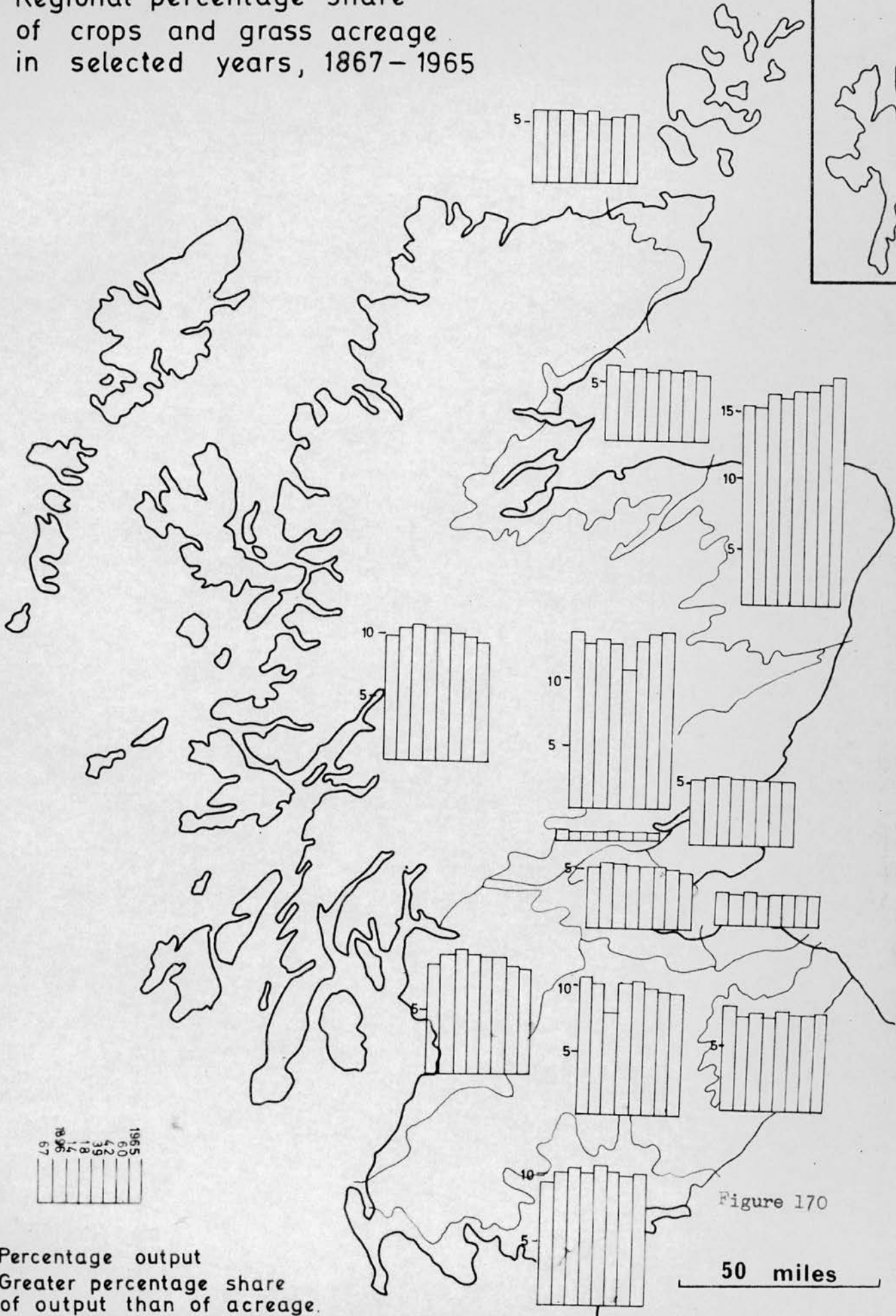


Figure 169

Regional percentage share of crops and grass acreage in selected years, 1867-1965



the averaging of yields for the highland-upland parts of divided counties into a general figure for the highland and upland regions. This would not have occurred if separate yield estimates had been available for low ground, upland and hill areas. The output pattern on the 1867 and 1896 must not be given full credence therefore. Contractions in the graph pattern in the Ayr-Clyde counties after 1918 are notable as farms in that area increased their dairying potential at the expense of some of their previous grain acreage. As barley became popular in other regions, the regional percentage share of acreage and output in the long established East Lothian regions has declined relatively but not absolutely. In fact the acreage devoted to barley in East Lothian has been increasing as elsewhere.

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The estimation of grain yields has become very difficult since the publication of official estimates of acreage yields has been discontinued. In recent years grain drying equipment has been installed on most of the larger farms in grain growing areas and facilities for storing high quality grain constructed on the farm. This means that estimates of the amounts stored and total production is most difficult. The primary producers prefer to store and hold their grain until the market is the most advantageous for its sale and quite rightly so. Recently, under a forward contracts scheme, the Home-Grown Cereals Authority has obtained a better measure of stocks on hand but the amounts consumed on the farm are unknown. The National Association of Corn Merchants are making a study of the situation. They do not know to a degree of

certainty how much grain will be available from local farm stored stocks, how much grain is produced in any one year, or in advance for what use the grain will be best fitted. Since there has been a move toward entry into the European Economic Community, the question of production is a vitally important one. The recent annual sales of upwards from 700,000 tons of British barley in 1965, to merchants in Rotterdam, Antwerp and Hamburg and up the Rhine to Duisberg and through the Italian ports of Genoa and Leghorn, have been made into the very heart of the EEC countries.¹ Since livestock densities are expected to rise in the Common Market countries, the demand for feeding grains is expected to continue rising. This prospect offers Scotland a continued outlet for surplus grain at a time when patterns are becoming less flexible due to specialization in a limited variety of crops. It is also a most convenient turn of affairs since the more northerly countries such as Scotland have few alternatives to grain, while countries further south on the European mainland may put their more expensive well-situated arable land to a variety of much more intensive use.

¹. A special report by Ottino, P. J., What Entry Into Europe Could Mean, The Times, January 26, 1967.

SUMMARY

The major problems in studying the patterns of grain distribution in Scotland 1866-1966 have been seen as methodological and representational. The physiographic face of Scotland presents an uncompromisingly rigid character of its own, bound to dominate any map form attempted. Many other northern countries share such a landscape and a methodological approach offers experiments which may be applied more widely.

The basic unit for all of the representational material has been the parish, for which statistics have been available throughout the century 1866-1966. Although the parishes vary greatly in size, no other useful administrative reporting unit is suitable to Scotland. In the past maps have been presented on the county basis but these are a poor reflection of the real patterns.

The census data will always have certain limitations. These are to do with difficulties ; in estimating sizes of units such as fields when they are not regular in shape or are fragmented; in applying the definitions which change occasionally over such a long period; of outlook of a farmer in lowland farms from another in upland or hill farms in classifying his property according to the categories; and problems concerning the number of returns reported annually and so on. There is little to be gained by an introspective examination of the problem of obtaining good census material. For the purposes of this examination, the year by year preparation of the material has been done as coherently as possible taking advantage of the corrections written into the census data by the statisticians and concentrating on checking

that the statistics apply to the same parish area throughout.

The aims have been few but they provide stringent limitations and harsh demands on representational methods. A search for multi-component representation was essential in order to be able to see a variety of related activity at one time over the entire country. A search for good areal comparability is basic to any representational research. It is all the more so in Scotland where the smallest reporting unit, the parish varies so widely in size. The patterns of distribution may not be so generalized that the statistical sources are entirely hidden, so a measure of data retrievability has been regarded as essential to the approach. All of the aims dominate and guide the approach to a number of specific representational methods.

Numerous problems were posed by the ambitious aims. Many forms of mapping give a static exclusive picture of one activity at a time, when the aim was for a multi-component and multi-dimensional representation. Most mapping is done on the basis of administrative units of unequal sizes since few countries collect census data on a grid system of reporting units, while the aim here has been to improve areal comparability. Few methods of representation allow for data retrievability and most seem to deliberately hide the statistical sources. The limits set provided a framework of approach where critical assessments could be made, as different forms of representation were attempted. The latter were deliberately arranged in a step by step fashion leading to forms which offered better results.

A great many maps have been used to represent distortions and misrepresentations which arise when different statistical approaches have been attempted. Percentage ratios are contrasted with actual acreage representations in density shaded maps to yield interesting results, with one suppressing one set of details and upholding others and the reverse. Different base reference units give vastly different impressions even when the same data is used for the same year. Some forms of representation do not relate well to others on subjects which may be important concurrently.

The single dominant problem throughout has been that of areal comparability. Salutory criticism was offered at the outset, of the approach to the use of statistics and the application of the data to different units of land as if the base premises were applicable throughout. On the basis of this valuable constructive criticism the parishes were grouped into highland-upland divisions of counties and more lowland divisions. The result was the 54 unit divided county and county map. This approach was confined to existing administrative boundaries except in a few cases where some long parishes cut across a variety of landscape from lowland to hill and these could be identified and divided after field examination. The approach proved valuable in a number of representational forms.

However, even this crude separation was not really sufficient and did not meet all of the aims. Some method was required to compare characteristic activity by parishes without the results being dominated by the vast size of one or the minute size of another. The unit area approach was

developed using methods which already existed but which had not been applied in quite the same way or over such a large diverse area. Since it was desirable to achieve a method which could be programmed and prepared by machine methods, stepped frequency surface diagrams were adopted and key maps provided to relate them to the formal map with its administrative divisions. The result has been to reproduce in the diagrams a miniature landscape with the characteristics of each parish represented. Large models were constructed to represent all of Scotland at once. The unit area approach is not difficult and the methodological approach has been deliberately directed to the practical solution.

The study of the patterns of distribution has continued the methodological approach and examined the advantages and disadvantages of one form of representation after another within the aims imposed earlier. A great deal of representational material has been offered and the commentary kept to a minimum so that the maps, graphs and diagrams are not duplicated in a lengthy prose description.

Throughout the century there have been considerable changes in the patterns of grain distribution. The period of optimistic expansion continued to the mid-1870's while demand for British grain exports remained high in Europe and before the United States was free of internal problems to take full advantage of the export market. A long period of decline on to 1914 brought hardship of the grain producer in the marginal areas where there were few or no alternatives to grain as a cash crop and imported grain was being sold more cheaply. The economic strain imposed by the 1914-1918

war and the government intervention through the Corn Production Act 1917 altered the grain growing patterns for a few years. The short recovery was followed by the difficult period of the 1920's and 1930's except for wheat which was protected under the provisions of the Wheat Act 1932 from cheap imports from abroad. Nevertheless, the 1939 position was exceptionally grave for the grain producer and represented a very low trough year of grain acreages. The Grassland Ploughing Subsidy of 1939 and the onset of the 1939-1945 war provided for a recovery which was phenomenal but ephemeral. The real revolution in the 1866-1966 century came with the use of increased amounts of fertilizers, weed, disease and pest controls, mechanization, new seed varieties and the like to increase acreage productivity in the last decade or so, to heights seldom equalled even in years offering ideal conditions. While the farm labour pool has decreased sharply, the output of grain farms has increased using expensive mechanized labour in the place of manpower. The result is that the grain offered for sale often obtains premium prices for its excellence, new markets have been found for its disposal and a great many of the larger arable farms of Scotland have been mechanized for grain production. The result may be cropping patterns which are less flexible to meet changing conditions and some loss of agricultural versatility but the choice has been in the direction of crops for which there is long experience and in many cases superb performances are commonplace.

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